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An Illustrated Weekly Journal

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A SERIOUS BUSINESS

ARE we getting to a situation in which engineering is too serious to be left to engineers? The question was put by Professor D. G. Christopherson, professor of applied science at Imperial College, in a B.B.C. talk last week. He took his cue from Talleyrand's famous saying, "War is too serious a thing to be left to military men." He explained that he was thinking not so much of the current obvious dilemma—the moral implications of the hydrogen bomb—as of the countless policy decisions in which engineers become involved: decisions which, for better or for worse, affect the lives of whole communities—even nations. Engineers have technical knowledge but they may not have enough wisdom to apply it properly.

Professor Christopherson suggested economics, sociology and philosophy as the kind of subjects that could broaden the understanding of an engineer and equip him for the full life which he is bound to lead if he reaches a position of responsibility. The same could be advocated, of course, for the non-engineers who exercise authority in engineering affairs. Two situations described by Professor Christopherson show very well why engineering by itself is not enough. The first example is taken from the modernisation plans for British Railways. The Transport Commission are electrifying some of the main lines, and introducing Diesel traction—either locomotives or rail-cars—on certain other lines. Engineering considerations are only a part of the factors which have to be examined in relation to the whole long-term aims. What, for instance, will the oil supply situation be in Britain in ten or twenty years' time? What price are we prepared to pay in order to achieve a cleaner atmosphere? What of the men who drive locomotives—will they take readily to special training, first for Diesel operation and later for electric operation? What will the unions' attitude be? How fast can the engineering industry supply the rolling stock and equipment for each phase of the plan and to what extent can the existing workshops of British Railways take part?

The second example comes from the work of engineers overseas, in countries which are being raised from a relatively primitive way of life to an industrial economy. In this case technical knowledge without a sympathetic understanding of the human factors can lead to untold difficulties and frustrations. In general, as Professor Christopherson says, "Every time we introduce or fail to introduce a new machine or a new process into industry, we start a chain reaction which affects not only those directly concerned—the management, the workpeople, the customers—but, in widening circles, every department of a national life."

It is unfortunate that human knowledge has to be divided into separate subjects which can be given a label. Outside the classroom, decisions are never based on the theory offered by one subject. The classification of knowledge by subject also leads to individuals being allergic to certain subjects, such as history or economics, which they could use with advantage. But if an engineer matures in his profession rapidly he finds that a knowledge of economics gives him a new depth of understanding. Like engineering, economics is not an exact science, but it enters into almost every question of policy in engineering. Product policy is partly an economic question; so is marketing, the choice of materials, the scale of production, the advertising and publicity plan. Economics is the standard measuring tool.

Philosophy may seem an odd subject to include but Professor Christopherson is not being academic in suggesting it. One of the biggest American companies has already sent its managers on courses which include philosophy. Like logic, it possesses an integrating power which other more specialised subjects lack. It helps a man to "make sense" of the kaleidoscopic picture from which the modern engineer cannot escape. At the British Association meeting Sir David Anderson advocated, in addition to logic, psychology and the writing of English. It is easy to argue that writing ability is acquired at school or not at all. But many people only begin to write with conviction when they have something concrete, something of their own thought, to write about; for engineers that means when they have been in industry for a few years.

Of all subjects, however, psychology is likely to be the most valuable in the next few decades. Though it is still a very inexact subject, and though it suffers from a certain unwelcome reputation, the time will undoubtedly come when it will be part of everyone's understanding. Psychologists themselves tend to be narrowly specialised, almost unable to converse with other psychologists in special fields and certainly hesitant at co-operating with engineers and managers. Engineers need not be dismayed by these additional demands on their intellects. On the contrary, they are in a far stronger position than economists, psychologists, sociologists, statisticians and the rest; they have the essential basic knowledge which the others find difficulty in acquiring. Some of them are now adding to this basic knowledge; many more will do so in the future. Engineering is already too serious a business to be left to engineers.

Cover Picture. *Rotary shears are an asset to the sheet-metal shop for cutting out irregular shapes without distorting the material. The photograph shows a machine cutting light-alloy sheet for use in forming aircraft assemblies.*

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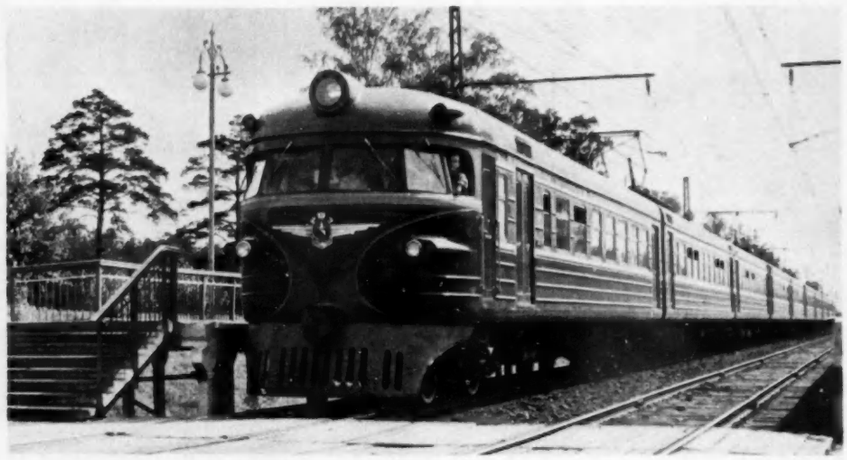
Plain Words

At the present time the odds are slightly in favour of the Free Trade Area coming into existence. If it goes through, it will align Britain with the countries of the European Common Market, except for certain reservations concerning trade with the Commonwealth. Granted that this is not a very good bet or risk (depending on one's point of view) the implications for industry are nevertheless exceedingly important.

The tactical position of British industry when the diplomatic exchanges take place—and perhaps afterwards, when the Free Trade Area is being brought into existence—is critical. It is probable that there will be a treaty of some kind worked out to cover broad principles on tariff reduction and related matters to which industry will have to adapt itself. It is imperative that individual companies should realise the kind of safeguards they need even if they fail to obtain all of them. Furthermore, the fullest information about competitors on the Continent and reasonable assessments of the market potential in a Free Trade Area should be worked out before D-Day. Irrespective of their country, those companies will do best in the Free Trade Area (within the limits of certain general circumstances dictating their industry's outlook) which are properly primed with economic and technical intelligence before the tariff barriers start to crumble and the free-for-all begins.

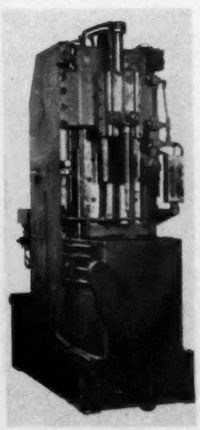
Information is still woefully lacking on how British industry stands in this matter. It is apparent from what people in industry are saying and from the statistical and academic work which has been done on trade prospects in the Free Trade Area that deductions based on information available so far are exceedingly tentative and by no means agreed. An interesting piece of research by Mr. H. H. Leisner in a paper called "The European Common Market and British Industry," given at the British Association, listed 60 industries in order of competitive advantage (based on past export performance) comparing the United Kingdom with its three strongest competitors in each industry. On this basis the strongest positions are occupied by aircraft, tractors, non-electric machinery for generating power and toilet preparations. The four weakest are listed as lead smelting, wood and cork manufacture, watches and clocks, and zinc. Plastics appear as number 11; cotton as 22; agricultural machinery as 24; machine tools as 39; iron and steel as 54 and cement as 55. These are examples taken at random and other analyses would put them in a different place on such a list. The truth is that the information is not available to reconcile the conflicting estimates which have been made and it is high time that it was.



Distances in the Soviet Union are so great that transport and communications have special importance. Said to have a top speed of over 80 m.p.h. and to reach 60 m.p.h. in less than a minute from starting, this electric locomotive hauls 10 air-conditioned cars seating 1,056 passengers.

St. Basil Cathedral in Moscow's Red-square represents the traditional values of Russian life. The modern aspect is symbolised by the industrial and scientific research establishments now scattered over the Soviet Union.

To some Russians the solar cooker is already more familiar than the samovar. The application of solar energy is one of many practical engineering studies performed by research institutes of the Soviet Academy of Sciences.



Vertical broaching machine MA1. Industrial research institutes keep a close eye on Western engineering practice.

EKG4 mechanical excavator designed to dig at a rate of 450 to 550 cub. metres per hour. The permanent industrial exhibition in Moscow serves as a living catalogue of new equipment.

HOW GOOD ARE SOVIET ENGINEERS?

The number of engineers now being trained in the Soviet Union has frequently been underlined in the reports of visiting delegations. Less has been said about their quality. Mr. E. P. Ward, M.A., A.M.I.Mech.E., a Deputy Editor of ENGINEERING, *has recently visited Moscow and Leningrad to seek an answer to this question. In an article published last week he introduced the Soviet engineer and sketched his background, referring to his place in industry, his contribution to Soviet life, his status and his tastes. The following article discusses the means by which he keeps his ideas up to date.*

2—HOW THE SOVIET ENGINEER KEEPS IN TOUCH

The designer with access to the latest information is better equipped than one without. New ideas quickly distributed are the key to technical success. In the Soviet Union as elsewhere the engineer is expected to keep in touch with current developments, and considerable efforts have been made to provide him with the means. Information services are comprehensive, systematic and centralised, and it is clear that special attention has been paid to the problem of communication.

Revising His Ideas

The nature of Soviet technical education has already been treated fully in ENGINEERING (vol. 181, page 134, 1956), but to be efficient an engineer must continue his studies after graduation. As explained in our article last week, extensive facilities for post-graduate work are provided in Russia, together with a ladder of further qualifications. Arrangements are also made to keep both workers and engineering staff informed of new technical discoveries.

For example, there is in Moscow an institute of further education, where courses are held to acquaint engineers and technicians with the latest scientific achievements. Many plants have their own schools or polytechnics, or at least " a house of scientific-technical propaganda " where visiting lecturers are invited to speak. Short courses, seminars and conferences assist in the constant revision of ideas. Once or twice in the average engineer's life he attends a refresher course lasting one year at an evening institute. At one factory it was stated that more than half the workers took evening courses, and many obtained diplomas. At another, 80 of the 440 technical staff were studying at institutes, while 120, mostly workers, were attending " Technicums " or technical colleges. At a third (ZIL—commercial vehicle factory) some 5,000 workers were employed in education, and shifts and classes were arranged complementarily.

Last week we referred to the procedure by which a diploma engineer can become an " aspirant," a " candidate " and finally a " doctor of science," and drew attention to the extensive original work required. Generous facilities for such work are provided by research institutes. At TSNITMASH (Central Scientific Research Institute for Technology and Engineering) for example, the aspirant is only required to work in the laboratory three days a week during his first two years of preparation, the remaining three working days being devoted to study. During this time he will receive a stipend of 1,000 roubles a month and half the salary of a junior scientific worker, making a total of 1,600 roubles a month.

What He Reads

The reading matter available to the Soviet engineer is vast and generally of good quality; but it seems likely that, as in other countries, more is written than can be assimilated. There are several sources of technical literature, each of which will be dealt with in turn.

Mashgiz is a state publishing house concerned mainly with mechanical engineering. It was formerly attached to the Ministry of Heavy Industry, but since Mr. Krushchev's reforms took effect the connection has been severed. Mashgiz publishes some 12 or 13 technical journals, including *Vestnik Mashinostroeniya* (" Mechanical Engineering Herald "), and others dealing with automobile and tractor engineering, welding, instruments, roadmaking and agricultural machinery, machine tools and metalworking, foundry practice, power plant and kindred subjects. The journals are produced economically, with comparatively poor illustrations and few advertisements, these in general being limited to one or two inserted by British and presumably other Western companies. The subject matter appears to be very much down to earth, graphs, tables and mathematics being widely featured. The journals carry no price indication and are distributed to interested bodies in the Soviet Union and abroad. Technical journalists, as is often the case in the United Kingdom, are qualified engineers with considerable experience in industry.

Specialist and general text-books are also published by Mashgiz, whose 1956 list includes some 430 titles, ranging from mechanics of machines, study of materials and cutting theory to automation, productivity and accident prevention. It should be emphasised that many texts prepared by such research institutes as ENIMS (machine-tool research institute) are published by Mashgiz; these include handbooks and booklets, written by specialists for specialists, on subjects useful to the practising engineer. Technical books are generally unpriced and are distributed to those likely to make use of them—factories, institutes and occasionally individuals. By directing literature to appropriate specialists in this way some duplication and wastage is presumably avoided.

Mashgiz is not the only technical publishing house and the journals mentioned are not the only technical periodicals. Factories, for example, occasionally produce erudite bulletins on technical matters, as do some firms in this country. Thus *Sbornik Electrosila* (collected articles from the factory Electrosila) contains quite as many graphs and differentials as a formal technical periodical. It is published on the company's behalf by Gosenergoizdat, the state publishing organisation concerned with electric power. There are also Metallurgizdat and various other special and general technical publishing houses. Factories also produce text-books for distribution to other factories, where experience can profitably be communicated. In addition monographs are published by technical bureaux. Thus notes and papers prepared by research workers at Tsnitmash are issued by the Central Bureau of Technical Information on Heavy Engineering. It is also significant that certain institutes, namely the Joint Institute for Nuclear Research at Dubna, which publishes its reports in duplicated form, requests writers to prepare their papers in both Russian and English.

The Soviet engineer appears to pay considerable attention to foreign journals. No factory or industrial institute I visited was without a copy of ENGINEERING in original or photocopy form, and many other British, West German and American periodicals were also represented. In the extensive library of the " Hammer and Sickle " metal factory, for example, I saw copies of the *Journal of the Iron and Steel Institute*, *Sheet Metal Industries*, *Industrial Heating*, *Wire and Wire Products*, *Power Engineering*, *Combustion*, *Power* and the West German *Metall*. These complete copies are likely to be supplemented by abstracts on special subjects prepared by research and other central organisations. The work of the industrial research institutes, which are a principal source of technical literature, will, however, be treated separately.

Probably the most striking example of information processing in the Soviet Union is the Central Institute of Scientific Information. This body collects, translates, abstracts and redistributes scientific and technical data published in languages other than Russian. It is also responsible for photocopying foreign journals for issue to factories and other organisations. This procedure would appear extremely uneconomic—besides a little unethical—but may be an attempt to save sterling and other foreign currencies. The quality of reproduction is good, and the photocopied ENGINEERING, though rather thicker than the original, appears in its familiar green cover, complete with advertisements. The paper is naturally coarser, but illustrations are fairly clear. I also saw the American journal *Power* reproduced in the same way.

His Research Services

Soviet industrial research organisations are not just vehicles for original work; they are nerve centres for the collection and dissemination of information and ideas. In addition, they are probably the effective organ of state industrial planning. They are vast, in accordance with these three functions, and frequently have the exclusive services of one or two associated factories. They are the second in a series of three types of research body. First there are the research institutes of the Academy of Sciences; second there are the " branch " or industrial institutes; and finally there are the laboratories (or sometimes complete institutes) attached to factories. All, including the first, are concerned with engineering problems, but range in mandate from the purely theoretical to the specifically practical, with the branch institutes mid-way between. Here I will refer particularly to the branch institute and its function as an information nexus, but other aspects of Soviet research planning will also be discussed. A complete article on the work of two research institutes will be published in a later issue.

The branch institute is so called because it is associated with a particular branch of industry; thus the rôle of Enims (Experimental Scientific-Research Institute for Machine Tools) is " to guide the construction of machine tools throughout the Soviet Union." It is also charged to maintain and raise standards of design; to gather together ideas and methods evolved in practical industry, to investigate them and select those deserving a wider application, and to publish and distribute the results of such studies throughout the machine-tool industry; to examine new developments in alien fields—electronics, chemistry, or hydraulics, for example, and to assess their potential application to machine-tool design or manufacture; to minimise duplication of production and research and development work; to check the characteristics of foreign machine tools, either before purchase or to ensure that Soviet tools are not inferior; to propose engineering standards; and finally to submit to Gosplan, the state planning commission, suggested production norms in numbers, types and the output of given factories. Some designs are also prepared by the institute. Tsnitmash performs a similar service for two sections of the heavy-engineering industry.

The means by which the institutes attack these tasks will be discussed fully later, but certain of their methods can be noted here. " Embassies " are sent out to centres of the machine-tool manufacturing industry to report on techniques developed locally and to assist in the application of those techniques developed elsewhere. Thus Tsnitmash has connections with some 800 factories. A model-making plant may be attached to an institute to provide small-scale mock-ups of proposed designs and factory layouts. An institute may have its own production plant for the construction of prototype machines, though by no means all prototypes designed by the institute are built in the institute's plant. I saw a large record book in which design data

for German, Swiss, British, American and other foreign machine tools were fully tabulated as criteria for comparison. In addition institutes issue to industry—sometimes by way of Mashgiz or another publishing house—texts, journals, data books, models, drawings, complete designs, or even prototype plant. They are well equipped, often with tools and instruments from abroad, and well staffed, and, as distinct from the two other kinds of research body, receive income both from above and below—from government sources and from factories which submit problems for solution. Generally, however, they receive more research commissions than they can undertake—perhaps twice as many.

Although the branch institute is also concerned with long-range problems, the broader theoretical studies are performed by the institutes associated with the Soviet Academy of Sciences. The Academy of Sciences should not be confused with scientific academies in other countries, which often simply provide a forum for publication, or serve as media for honouring respected scientists. The scope of the Soviet Academy is immense and its function practical. Though certain abstract studies are carried out, it is generally with a view to useful application. Thus Academician P. I. Kapitsa's institute, which is concerned with low-temperature physics, keeps an eye on such problems as the distillation of oxygen from air, and heavy hydrogen from natural hydrogen, and the design of relays or " memories " for computers. Another institute studies underground gasification of coal—a principle widely believed in the U.S.S.R. to have been proposed by Lenin. The pavilion of the Academy of Sciences at the permanent industrial exhibition in Moscow includes such practical exhibits as electro-erosion tools and solar cookers. There are some 50 affiliated institutes in Moscow alone, though recent public statements, including one by Kapitsa, have suggested that dispersal of institutes throughout the U.S.S.R. would better serve the public interest.

Thirdly there are the institutes, laboratories and libraries attached to factories. For example, such problems as continuous casting, vacuum casting, simultaneous broaching and heat treatment of special steels, and high-speed cutting are tackled in the " Hammer and Sickle " metal works in Moscow. The First State Ball Bearing Factory has its own research institute and, as in other countries, all factories of any size have their own laboratories and libraries. Teaching institutes also have research departments, but in general these have not quite the same functional significance as university research departments in this country.

Finally, there is the research " commando," which may include representatives of all three research groups. Though already familiar as an *ad hoc* procedure, such commandos have recently been given formal recognition, and may soon be a regular feature of Soviet industrial operations. Writing in *Pravda*, Academician Kapitsa proposes that " parallel with existing thematic scientific research institutes, we should now begin to set up problem scientific-technical organisations of large and small scale. Each such organisation will engage in the solution of a quite definite urgent problem. . . . As these organisations will be of a temporary nature, it will be easy, if need be, to organise them in those areas where the problem requiring solution is most urgent and more closely connected with the demands of life. . . . It is necessary to foster and stimulate in our scientists and in some foremost engineers, a sense of mobility. Such an organisation for the solution of scientific and engineering problems may be visualised as a mobile combat force made up of units of the various services. Such a force is given a definite operational assignment, after the accomplishment of which it should again be reorganised in conformity with the requirements of the next assignment." This statement was in accordance with the new doctrine of decentralisation outlined by Mr. Krushchev.

It appears that applied research is a cornerstone of Soviet policy—to the extent that research procedures and their organisation have become a field of systematic study. This is not surprising. Central to the Communist philosophy is the concept of planning, and without efficient information services planning is impossible. It is thus quite logical that the branch institutes, which are primary sources of technical information, should also be the organs of industrial planning. The man who knows most about a situation is best equipped to formulate a course of action. It also follows that the industrial institute is the most suitable agent for the distribution of information and the cross-fertilisation of ideas.

The disadvantage of concentrating functions in this way is that the organisations themselves may become unwieldy. Enims, for example, has a staff of 2,450, including employees in the associated plants, and Tsnitmash 4,000 of whom 2,500 work in the institute itself. While in Moscow, I discussed the problems of planning with Academician Kapitsa; I gathered that everything depended on the quality of the plan. He believed that the new techniques of data processing were likely to favour a planned system. Planning, he told me, was by no means incompatible with initiative and would become decreasingly so; in engineering it was almost second nature.

Scientists sometimes pretended that they were engaged on " pure " research, to ward off interference from outside, but science could never be really detached from practical considerations. Even the most abstract concept could have practical—if not disastrous—results. Freedom in science and research was purely relative. Knowledge was to-day so overwhelming that one was forced to choose a limited field of work; and since certain fields were likely to be more useful than others, these were generally the ones in which work was most active. Thus two branches of mathematics were theory of numbers and calculus; until recently little use had been found for theory of numbers and it was consequently neglected, while calculus flourished. Kapitsa's view is probably representative of current Soviet thinking.

Soviet research—even by the Academy of Sciences—is unashamedly " applied," and vast resources are devoted to it. The results are now beginning to emerge.

Letting Him Know

In a country the size of the Soviet Union communications assume a special importance. Size is in fact a major condition of Soviet development and will be treated in a later article. Britain is compact and though this may create special problems in the organisation of transport, it is at least potentially an advantage. To minimise this difference, the Soviet authorities are making great efforts to improve rail, air and marine communications. The development of high-speed passenger aircraft is an example of this policy; and a recent report—true or false—illustrates its importance. It was said that a change of government might have taken place in the absence of Mr. Krushchev abroad, had Marshal Zhukov not in a few hours gathered together the full voting strength of the Central Committee from all parts of the U.S.S.R. by jet aircraft. Centralisation, with decisions waiting on Moscow's instructions, merely adds to the difficulty of administering large areas. The recent introduction of 106 economic regions with semi-autonomous powers may be an attempt to relieve the situation.

But centralisation can also have its advantages. The permanent industrial exhibition in Moscow assembles in one place engineering products from the entire country. An engineer with time to spare and the fare to Moscow can examine current developments in his own and other fields, and return home with a much clearer picture than he could hope to achieve by correspondence. Exhibits are frequently brought up to date, and include not only established and tested products but also experimental models. The visiting engineer may discover methods and ideas which to him at least are new, learning for example that petrol can be made into a solid emulsion for transport purposes. If he is awed by nuclear science he may inspect the Cerenkov radiation from a swimming-pool reactor, or enter a mock-up of the captain's cabin for a projected atomic icebreaker. There he may notice that the captain has two beds, one set at right angles to the other; he will be informed that this arrangement is to ensure the captain's comfort, one bed to be used when the ship is pitching and the other when it is rolling.

Earth-moving equipment and other heavy items are displayed in the open air, where fountains and boating lakes provide decorative contrast. The exhibition has the roccoco touch of Battersea Pleasure Gardens; its purpose is not only to instruct but also to present engineering to the public in a sympathetic light.

Public relations, even advertisements, appear to be assuming increasing importance in the U.S.S.R. The Russian authorities, I was told, are learning that it pays to advertise. It was not enough to inform the engineer that such a machine existed; it was necessary to catch his eye again and again. In a few years, perhaps, the political slogans will disappear to be replaced by the brave colours of the advertising man. Soon it will be difficult to distinguish East from West.

* * *

RUSSIANS PREFER PACKAGE DEAL

Russian orders for the supply of machinery worth £7½ million have been awarded to a new name in British engineering, Rustyfa Limited. This is a consortium formed by David Bridge, Francis Shaw (both rubber and tyre plant specialists), Crompton Parkinson, Lancashire Dynamo, and Mather and Platt. The order is the first instalment of equipment required for a new tyre factory being built at Dnepropetrovsk in the Ukraine. Rustyfa, which stands for Russian Tyre Factory, was formed at the end of 1956 especially for this job. Deliveries are to start early in 1958 and the plant is to be commissioned two years later. It will be one of the largest in Europe, with a capacity of 2 million tyres a year. Lancashire Dynamo will supply the electric motors for the large rubber machines, Mather and Platt the rayon dipping, refrigeration and water circulating plant and Crompton Parkinson the switchgear and electric motors for auxiliary equipment.

Successful trading in markets where the buying is done by large Government agencies is becoming more and more dependent on a collective approach by companies offering a complete range of equipment. The group which can offer to build a whole factory stands a much better chance of getting the order than the firm seeking to sell one specialised item of plant. This is becoming so even in Britain, where, for example, all contract awards by the C.E.A. for nuclear power stations have been to consortia of large firms able to design, construct, equip and commission the entire plant. The reason in this case is doubtless the intricacy of the designs —and the major problem of building something new which requires the closest co-operation between firms of specialised skills and experience.

In overseas markets British consortia have done well for these and additional reasons. In India and other under-developed countries it is of considerable advantage to put forward a complete steel mill, and essential to have considerable financial resources to undertake so large a contract. It is also necessary to negotiate with one buyer—in this and most similar cases, the Government of the country concerned or a specialised national agency—on technical and financial points. This is done much more easily by a small committee who have an overall view of the scheme. In addition, there is in most of these countries a lack of skilled designers and planners; and the suppliers of plant able to offer such services are likely to score heavily.

Automobile Engineering

LIMITS TO RATIONALISATION

With the abandonment of the Riley Pathfinder, the last technical traces of the old Riley company, which produced many good and interesting cars, have disappeared. It seems a pity that in the vast range of vehicles produced by the B.M.C. no place could be found for continued development of engines with hemispherical cylinder heads, but the use of a twin overhead camshaft engine in the M.G. single-seater which has just set up new speed records in Utah suggests that what has gone out by one door may eventually return by another.

Meanwhile, the Riley Two-Point-Six becomes almost indistinguishable from the Wolseley 6/90, and from the engineering point of view there seems no point in making it. It not only has the same six-cylinder engine, replacing the Riley four-cylinder; it also has the same body structure instead of the lower-built version previously employed. The answer lies in the need to provide Riley dealers with something to sell. The light commercial vehicles of the group are already sold through both Morris and Austin dealers, and the big Princess limousine is now a generalised B.M.C. product, sold by Austin and Nuffield dealers in competition with each other.

Another facet of the same problem is illustrated by the launching of the Edsel car by the American Ford group. In the United States, social prestige seems to be closely related to the known cost of one's car, and the Edsel plugs a gap between Ford and Mercury, so that a Ford owner receiving a rise in salary, or getting a better job will not need to buy a product made by General Motors or Chrysler group.

Girling Limited, have transferred their entire business in power-assisted steering to Hydrosteer Limited, of Luton, who will continue to manufacture and service Girling designs and their own, while investigating commonisation of design and rationalisation of production; growth of power-assisted steering business has been very much slower than was originally anticipated and total output is not sufficient to sustain economic production of the two separate systems. Hydrosteer Limited, as a subsidiary of Cam Gears and George Kent Limited, are in a better position than Girling to sell steering gear with power assistance. The smaller size of cars and commercial vehicles in Europe is an obvious reason why power steering has not had the success it has achieved in the United States, but one engineer working on power steering installations recently offered as another reason the cantankerous attitude of the British worker. He mentioned instances where the introduction of a few vehicles with power steering into a fleet had produced so much jealousy and unrest among drivers of the remaining vehicles that the owners preferred to abandon power assistance rather than to increase efficiency at the expense of their labour troubles.

Letters to the Editor

THEORY OF NETWORKS

SIR, With reference to the letter from Mr. F. E. Rogers (ENGINEERING, September 13, page 325), it is to be regretted that certain passages in my review of his book *The Theory of Networks in Electrical Communication and Other Fields* are open to a misinterpretation in matters of detail, as is shown by the valuable comments of the author. These comments are referred to *seriatim* below.

(1) *Insertion Loss and Network Design*

It is correct that attention is given to the insertion loss of filters, but so long as the theory of filter networks is approached through the analysis of the uniform transmission line it inevitably follows that the concept of insertion loss is secondary to the concept of image attenuation constant, even though the two are defined independently. The iterative network, designed directly to yield a given insertion loss, is widely used in equalisation and the design is carried out on this basis because it is clear, simple and convenient. It is thus incorrect to suggest that iterative parameters are only useful for the analysis of recurrent structures, and, therefore, it is not possible to agree with Mr. Rogers' remarks on this topic and on asymmetrical structures. Although the author rightly claims to have dealt with the insertion loss of some networks other than Zobel filters, he has thus ignored an important group of networks, and, in comparison, the other treatments he mentions are only trivial.

(2) *Image and Characteristic Impedances*

The definition of characteristic impedance on page 367 of his book begins: "The iterative or characteristic impedance of a symmetrical four-terminal network. . . ." On page 372 the opening sentences of the first paragraph on asymmetrical networks read: "To an asymmetrical network must be attributed two unique values of characteristic impedance . . . These impedances are more aptly termed the input and output Image Impedances." As Mr. Rogers explains in his letter, there is no treatment in the book of the asymmetrical iterative network, and in a symmetrical network the iterative and image impedances are identical. Therefore, there is no opportunity for a student to discover the differences between these two impedances or the reasons why two definitions and concepts are used.

(3) *Matrix Methods*

The change from determinantal to matrix methods may be carried out as a mathematical exercise. However, Guillemin has clearly demonstrated that the fundamentals of network analysis may be so treated as to lead naturally to matrix analysis, there being no point at which the student is isolated from network concepts. That is, the student learns a series of mathematical processes based on physical arguments and only when these are formalised in notation is he aware that he has been manipulating matrices. This approach seems far more suited to the teaching of engineering students than the one recommended by Mr. Rogers.

Yours faithfully,
YOUR REVIEWER.

September 12, 1957.

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SIR CYRIL KIRKPATRICK

Sir, In the various obituaries of Sir Cyril Kirkpatrick (See ENGINEERING, September 6, page 295) I have seen no reference to a work of his of which we have a duplicated copy in this library. It is called *Notes on the life of Frederick Marriott, with Particular Reference to the Part He Took in the Early History of Flying*, and Sir Cyril's interest was that Marriott (who was associated with W. S. Henson and J. Stringfellow and was also interested in aeronautics in his own right) was Sir Cyril's grandfather.

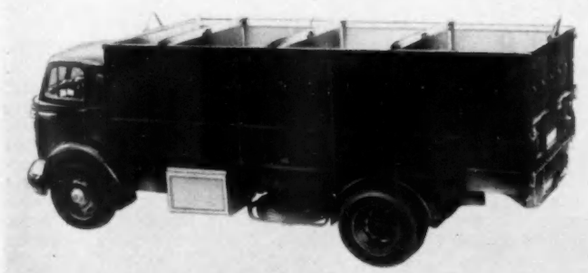
Yours faithfully,
F. H. SMITH,
Librarian.

The Royal Aeronautical Society,
4 Hamilton-place,
London, S.W.1.
September 6, 1957.

BULK LOAD OR GENERAL FREIGHT LORRY

Built-in Blower for Granular or Powdered Materials

Manufactured by R. Murfitt Limited, Outwell, Wisbech, and marketed by O. G. Barnard and Sons, Limited, Station-road, Stowmarket, Suffolk, the "Barfitt" bulk transporter incorporates suction and blowing equipment for loading and discharging granular and powdered material in bulk, and can also be converted quickly to a normal type of high-sided vehicle. In the latter form it can be equipped with a "Telehoist" loader for sack handling.



The "Barfitt" transporter has power loading and unloading gear for bulk granular materials. It can also be used as an ordinary hand-loaded vehicle.

The body, which can be fitted to any commercial vehicle chassis, is based on a framework of extruded aluminium alloy sections, is double-skinned, with 10 s.w.g. interior and 20 s.w.g. exterior sheets, also of aluminium alloy. The front and sides are rigid; the rear has an 18 in. hinged tailboard, with van-type doors above, folding back on to the sides for easy access. Rubber seals are fitted to make the body completely tight against all granular and powdered materials. A ridge wire, supports and rope hooks enable a waterproof canvas tilt to cover the entire top of the body. Alternatively, for loads such as malt or cement, a special fitted alloy top cover can be supplied. Aluminium-alloy internal partitions are provided, and these can be adjusted along the body to suit the loads, or they can be removed altogether to accommodate a single bulk load, or to allow the vehicle to be used as an ordinary lorry.

POWER LOADING AND UNLOADING

Loading of bulk granular or powdered material can be effected by suction from the blower mounted on the vehicle, and driven from the gearbox power take-off. Grain can be handled at a rate of 12 tons per hour.

For discharging bulk loads the same blower can be used, the body being tipped by means of the integral Telehoist tipping gear until the material falls into a screw-type impeller extending across the width of the body at the rear. This feeds it, through a patented rotary seal, into the airstream from the blower. Two 10 ft. lengths of flexible hose are supplied, complete with quick-release couplings, to take the discharge to the required point. The blower is capable of elevating to heights of 80 ft., and will discharge grain at 15 tons per hour. Cement can be blown out of the vehicle at 40 tons per hour.

Metals and Materials

MATERIALS PIONEERED BY THE AIRCRAFT INDUSTRY

New steels for the aircraft industry include Jethete 151, a high-tensile weldable ferritic stainless steel with low thermal expansion and good strength, creep and rupture properties, suitable for temperatures up to 550 deg. C. and envisaged principally for aircraft engine structure. The steel can be formed without heating and is readily welded by all the usual methods. This is a development of Samuel Fox and Company, Limited, Sheffield; another product of this company, Fox 769 steel, with a tensile strength of 100 to 110 tons per sq. in., has the highest tempering temperature for a steel of its kind and has been developed for undercarriage and airframe-structure forgings.

A development by William Jessop and Sons, Limited, Sheffield, is the vacuum-melting process for steel castings, which produces a casting free from non-metallic inclusions and impurities, giving improved ductility, particularly transverse to the grain. It also enables a closer control to be kept on the gas content and chemical composition, and opens up new fields of alloy development. Among its immediate applications are ball races, compressor and turbine blades and discs, high-grade polished sheet, and precision tools and dies.

A new chemical nickel-phosphorus plating process is in operation at the Oldbury works of Albright and Wilson (Manufacturing) Limited, 1 Knightsbridge-green, London, S.W.1, known as Kanigen plating, which is claimed to be hard (Vickers 1000 after heat treatment), corrosion and wear-resistant. Considerable weight savings can often be effected by using Kanigen-plated titanium or light alloy in engine components and control valves, and tests carried out recently on Kanigen-plated experimental titanium rams and cylinders by the de Havilland company indicate that the galling tendencies associated with titanium alloys have been eliminated. The process is approved by the Ministry of Supply and the Air Registration Board.

SYNTHETIC RUBBERS

The early grades of silicone rubbers suffered from relatively poor physical properties but advances during the past year have been substantial. Precision Rubbers Limited, Bagworth, Leicester, are now offering their Prescolastik in a range of hardnesses. General-purpose, low-temperature and low compression-set grades are now being manufactured, and high-temperature and high tensile-strength grades are available on an experimental basis. A range of cellular silicone rubbers is also under development. All grades are claimed to show outstandingly stable physical properties over the temperature range −60 deg. C. to 200 deg. C., with immunity to ozone and weathering, non-stick and non-corrosive surface and good electrical properties. Further, silicone rubbers can be supplied in white with high reflective power. Also available are Prescolastik silicone-rubber seals for airframe applications, which can be produced with metal, plastics or fabric reinforcement for additional strength.

Oil-resisting high-nitrile Butakon rubbers will be in production by Imperial Chemical Industries Limited towards the end of the year, particularly suitable for fuel tanks, oil seals and hoses.

PLASTICS PARTITIONING

Bristol Aircraft Limited, Filton, are already well known as producers of plastics drop tanks, missile cases, pressure bottles, and radar scanners and radomes. Now they are venturing into the general constructional field with a new type of partitioning material fabricated from resin-impregnated glass cloth, which they refer to as a "honeycomb sandwich." The examples seen at the Society of British Aircraft Constructors' exhibition recently, however, could hardly be said to resemble a honeycomb. They were of cellular construction, with parallel outer walls moulded integrally with perpendicular stiffening members. The material can be produced as flat sheets, or with simple or compound curvature and any desired colouring can be built-in with the resin. Bristol are recommending the material particularly for ship-board partitioning since it is immune from sea-water corrosion and requires no maintenance.

GLUT OF NON-FERROUS METALS?

A recent review of the position and prospects in the non-ferrous metal industries of the United States caused *Business Week* (August 17) to conclude that "as prices slide and demand falters, most non-ferrous metals are in over-supply. The industry's earnings are down, and its only short-term hope is an upsurge in the economy." The request for an increase in the import duties on lead and zinc, recently backed by President Eisenhower in a request that the Tariff Commission should "expedite its consideration of the matter," suggests that the industry is indeed on hard times. The presentation of a Tariff Bill to deal with the situation instead of going through normal Tariff Commission channels was, the President said, due to the outlook of the industry "represented to me as being so critical as not to allow the time for a Tariff Commission investigation."

These are alarming words for a President of the United States to use about an industry. But there is little doubt that it reflects accurately the feeling in the country. The market value of leading companies' shares lost between one-fifth and nearly one half of their value and prices of the metal have slumped heavily. Those of copper, lead and zinc have now fallen to their 1953 level and there seems to be no definite sign of recovery. On the contrary further declines are expected.

The explanation for so radical and depressing a change in the situation was given in respect of zinc by the two leaders of American Smelting and Refining Company in their report on their company's disappointing first half-year's earnings: "... the market situation in zinc especially has been characterised by world-wide expansion of production without corresponding increase in industrial demand and by reduced Government purchases." But there are weaknesses also in the demand for aluminium, copper and most by-products, such as selenium. The twin effect of a fall in car production and a reduction (in some cases a complete stoppage and some selling) in stockpiling by the Government, has been too much for these industries. They have been caught almost unawares, with prices on inflated levels (which bear little, if any, relation to costs) and with much of their fields invaded by substitute materials developed in the long period of acute shortage. In so far as the falling prices indicate a return to more normal competitive position, they should be welcomed. There would appear little reason for any other view, but if stockpiles are forgotten and new applications take their place, industry should benefit the world over.

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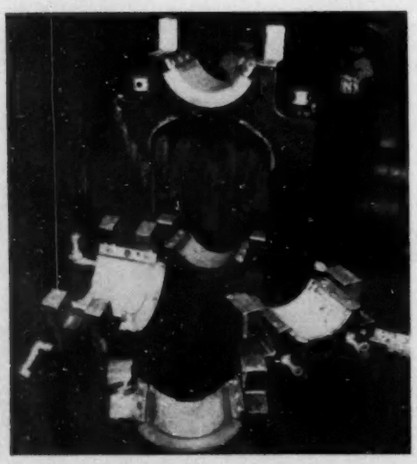
STAINLESS-STEEL CLAD ROLLS

A new method for the external cladding of rolls, shafts, tubes and drums with stainless steel and other similar alloys is now in production at the works of Rose, Downs and Thompson Limited, Old Foundry, Hull. This process, which is patented, and, it is stated, has been fully proved on the Continent, enables a perfect bond to be obtained between the cladding and the parent body. It is emphasised that the cladding process is particularly advantageous in the case of internally-heated or cooled rolls and drums, which, after cladding, are suitable for operation in a wide range of temperatures. Clad rolls, moreover, can be ground and polished to precision limits.



Liners and thrust collars for a rolling mill, made of a new synthetic-resin material.

SYNTHETIC-RESIN BEARING MATERIAL

A new synthetic-resin fibre-reinforced bearing material, "Orkot," having been tested extensively in rolling mills belonging to the United Steel Companies Limited, has now been placed on the market by their subsidiary, the United Coke and Chemicals Company, Limited, 34 Collegiate-crescent, Sheffield, 10.

Orkot bearings and thrust collars can be manufactured to any size required, and the excellent moulding and machining qualities of the material allow high dimensional accuracy to be maintained. The material possesses the three essential characteristics required for rolling mill work, very low friction coefficients, high resistance to wear, and high compressive strength. As a result, not only have improvements in bearing life been recorded under test, but economies in power consumption and improvements in material-size maintenance have also resulted. Orkot has a tensile strength of 10,500 lb. per sq. in. lengthwise and 7,500 crosswise.

The compressive strength, flatwise, is 36,000 lb. per sq. in., and the shear strength 14,500 lb. per sq. in. Other physical characteristics are: Young's Modulus $0{\cdot}55 \times 10^6$ lb. per sq. in., impact strength (Izod) 3·5 ft.-lb., hardness (Rockwell M), 110, specific gravity 1·25. The material is designed primarily for water lubrication, and an adequate supply of clean water should be available. At very low rolling speeds the water film tends to break, and additional grease lubrication is recommended. Bearing life depends largely on the condition of the roll necks, and water-repelling oil should be used when stopping the mill; this oil will help to maintain the roll necks in good condition, and so prolong the life of the bearings.

Companies in the News

Bids to be Different

The progress of some companies since the war into new fields has been such that they can barely be recognised. The diversification of the John Brown group was described in our issue of August 23. The progress made by companies such as English Electric, Imperial Chemical Industries, Distillers, Rolls-Royce and most other industrial leaders in diversifying their output suggests that such a policy will repay good dividends. Who can tell now, for example, what the new Courtaulds/British Celanese group will look like in two decades or, for that matter, the oil companies as the threat of new fuels becomes more concrete in 20 to 30 years? There will be major changes, and as a result probably some considerable overlap of large companies in new fields. There are examples of this already in chemicals and nucleonics, and non-ferrous metals.

There are always more factors at play in producing such basic changes than can be detected at first sight. The need to invest large sums " in something " is certainly one factor, and will increasingly become one for the biggest of our companies. So is the wish to spread the dependence of a company over so wide a field that their prospects are, in effect, the prospects of the whole economy. The next step, already taken by several leading engineering companies (Hawker's come to mind) is to invest in overseas developments to offset even national fluctuations. With skill and ample resources a large group can become almost unshakable.

The pursuit of diversification is in evidence in three company reports published recently: British Electric Traction, whose chairman, Mr. H. C. Drayton, is one of the leading " group" builders in the country, are now not only in road passenger transport on a world-wide basis, but also in commercial television (Association Rediffusion), rental of television sets (Broadcast Relay Services), in laundries and other fields, in Canada as well as in this country. Mr. Drayton expresses the belief that this diversification will pay handsome dividends within " the next two or three years." Thorn Electrical Industries draw much of their strength from the fact that they have expanded from radio and television receivers into electrical lighting accessories and, more recently, electric cookers, aircraft equipment, plastics, furniture and (with Sylvania) high-purity silicon for transistor and rectifier manufacture. Like Mr. Drayton, their chairman, Mr. Jules Thorn, considers that diversification will pay, and that overseas investment is eminently worth while.

The third company, Powell Duffryn Limited, have achieved considerable success in investing their coal compensation assets in new fields. They are leading coal and oil distributors, shipowners, brokers and agents, and have developed large engineering interests including the building and repair of railway wagons, oil-storage tanks, graphite products (including heat exchangers and chemical plant), heating systems and oil space heaters, colliery plant, etc. As their chairman, Mr. H. Wilson Smith, states in his annual report " these developments represent a formidable list " and cover " a wide range of diversified activities." With capital commitments exceeding £3 million, Powell Duffryn can justly claim to be a " virile and progressive group."

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Cross Currents in Machine Tools

During June deliveries of machine tools totalled £7·58 million which was a fall of 12 per cent. on the month but an increase of nearly 19 per cent. compared with June, 1956. New orders booked during the month were also fewer than in May, both for the home and export market. The order book at the end of the month was £90·12 million compared with £91·47 million at the end of May and £105·23 million in June, 1956.

Over the last 12 months the order book for the industry as a whole has steadily, if gradually, declined and at the present rate of deliveries it represents just over 12 months' work. The trend of the order book is indeed much more apparent than either the rate of deliveries or the rate at which orders have been booked so far this year. Compared with a year before it is the deliveries which have been speeded up rather than orders which have fallen, although there is no doubt that in May and June, for example, the value of orders received was smaller than in the earlier months of the year. As was pointed out in a note last week on page 337, the industry is fairly optimistic about its prospects. It is much too early to say that any slight easing in the pace of activity in the industry has been brought about by the slowing up in the rate of capital investment towards the end of last year.

The picture is in fact quite confused. There is this uncertain trend in deliveries and new orders. On the other hand, if inflationary pressure continues it may be increasingly difficult for the industry to get more labour or even hold all that it has attracted in the last 12 or 18 months. If this should be so there might be a slackening in the rate of delivery and an increase in the backlog of orders. At the moment, therefore, the outlook for the industry is fairly set at " fair" but it is exceedingly difficult to tell in which way the economic weather is moving—whether it is steady or slightly less settled.

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Profits in the Air

B.O.A.C.'s results for the financial year ended March 31, 1957, showed a very slight increase in the level of profits before remuneration of capital from £1·3 million to £1·8 million. After provision has been made for remuneration of capital, however, the profit last year was at the modest level of £303,000 compared with £118,000 last year. This slight advance has been recorded in a year which saw an increase in revenue of 14·8 per cent. and an improvement in the average overall load factor from 61·7 per cent. to 63·7 per cent. By most rule of thumb indicators, therefore, the year was a successful one in terms of turnover and efficiency. In terms of profitability, however, the results left something to be desired.

Just how substantial are the risks and the large capital investment programme which face all international airlines can be seen from the remarks of the managing director of B.O.A.C. in a message to the staff last week. As the first of the Britannia 312s was accepted from the manufacturer he pointed out that even if the delivery dates given by the manufacturers are now met, the delay in the delivery of the Britannias will reduce turnover this year by over £2 million. There were also hints that a certain amount of adjustment had still to be made to the aircraft in its proving flights.

It is clear that the present level of international air fares gives no margin for circumstances such as have surrounded the production and delivery of the Bristol Britannia—circumstances which could well repeat themselves in the case of jet aircraft to be delivered over the next few years. The issue is now one of subsidy for the taxpayer or higher air charges and a decision cannot be delayed for much longer.

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Aircraft Business

Despite the position described in the last note, there is the beginning of a feeling in the aircraft industry that things may not be so bad as was feared six months ago, just after Mr. Duncan Sandys had visited the United States to talk guided weapons. Since then British firms have done remarkably well with their civilian aircraft —Bristol Britannia, Vickers Viscount and Vanguard, and now the de Havilland Comet IV. The announcement of a contract concluded by Hawker Aircraft with the Indian Government for the supply of a " substantial number " of Hunters—between 100 and 200 aircraft valued at approximately £200,000 each was mentioned—is a reminder that military types can be most valuable earners of foreign currency.

In the field of aircraft components also the British industry is exceeding its own hopes. The recent announcement by de Havilland Propellers of a large Canadian order for the supply of propeller equipment for the new Canadian turbine-powered aircraft, the Canadair CL44, suggests that in this field at any rate British designs are leading. The new aircraft, which is derived from the Bristol Britannia, will be built in air-liner, freighter and auxiliary transport versions.

When considering the future prospects of the aircraft industry, the comments of Mr. Eric Turner last month in his statement to the shareholders of Blackburn and General Aircraft Company are worth quoting: "... whilst it is obviously right that account should be taken of the latest scientific developments, I cannot help feeling that some manned aircraft will remain in service far longer than is sometimes imagined . . . it does not seem conceivable that guided weapons can replace manned aircraft, whether sea-borne or land-based, in the foreseeable future, and it also seems certain that the need will continue for military transport aircraft, helicopters, reconnaissance aircraft, trainers, and, of course, civil aircraft." As Mr. Turner rightly points out, there will be an overall reduction of demand for military aircraft, but enough will still be required to continue to make it possible for the leading companies to do well.

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Fluctuating Fortunes in Metals

The remark of Sir Arthur Smout, chairman of Murex, that the outlook for nearly all their major activities is " most encouraging " will please those shareholders who have long been awaiting the moment when they would reap something substantial.

The company has repeatedly been troubled with the fluctuating prices of raw materials. Last year was no exception—profits fell by £230,000, from £579,000 in the year ended April 30, 1956. The explanation given is that the continuous decline in the price of wolfram ore resulted in heavy losses on turnover of stocks, accentuated by a falling off in the demand for tungsten products. Developments in new fields, however, are highly promising. Sir Arthur Smout mentioned particularly pure tantalum and niobium powders, for the production of which a new factory scheduled to come into service in 1959 is being built at Rainham. Current demand is being met by the output of a pilot plant. Niobium, which forms part of a group of refractory or high melting metals, is of interest in the field of nuclear energy and was chosen as the canning material for the Dounreay fast-breeder experimental reactor. Capital expenditure is on a fairly large scale. Last year £915,000 was authorised on new fixed assets. But much remains to be done and there is little doubt that additional capital will be sought in the near future. The decision to shelve the plans for a new zirconium plant " pending clarification of probable demand and availability of world supplies " is an indication of the kinds of pressures against available resources. There is little doubt that the outlook for what may be described as " the newer pure metals is outstandingly good." But development costs are heavy and the development period can be very long unless large resources are employed.

Plant and Equipment

POWDER PRESS

The introduction of powder metallurgy techniques brought with it the need for a machine which would compress the powder into the shape of the finished product ready for sintering. One firm making such machines in this country is the Apex Construction Company, Limited, 15 Soho-square, London, W.1, who have recently put an improved model on the market.

This machine, model 146/5, has a capacity of 40 tons, and has provision for three separate motions. There is the upper punch which moves downwards, and there are two concentric lower punches which move upwards to compress the powder, but which have independent motions so that different shapes can be formed during compression.

The movement of the punches is controlled by cams driven from the main shaft, the followers being kept in contact with them by pneumatic cylinders. There is one cam for each punch, but the most recent version of the machine incorporates a separate cam which is used to carry out the ejection stroke, on the main outer punch. The ejection follower is kept against the cam by a spring, and a striker on the follower lever makes contact with an anvil (the height of which is adjustable) on the main lower punch operating arm. As in earlier machines, the movement of the punches themselves is governed by inserts which can be bolted on to the base-circle cams to give the required movement and dwell for each particular operation. Pressure can be applied to the powder both from the top and the bottom, either simultaneously or non-simultaneously. The latter is found necessary when flanged pieces are made, as the top punch must seal the powder in the die before the bottom punch starts compressing; alternatively, top pressure alone can be used.

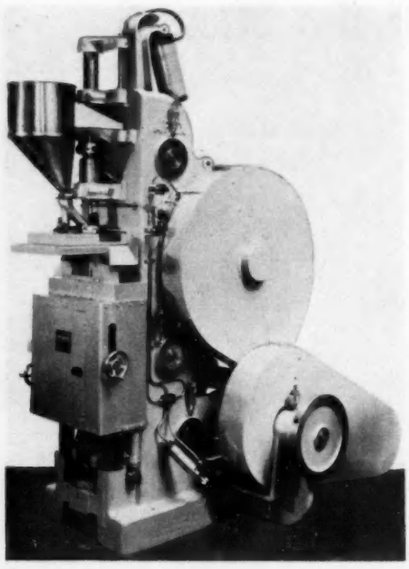
CHOICE OF PUNCHES

On standard machines there are one upper punch and two bottom telescoping punch mechanisms. An additional stationary core rod can also be fitted. The inner bottom punch can be used as a stationary core rod, a movable core rod, or a secondary lower punch. This enables pieces with flanges, concentric projections, through holes, or blind holes, to be produced. Since each punch is separately controlled by its cam, pieces of uniform density are produced even when the part has different pressure levels required by its varying sectional thickness.

The stepless stroke adjustment fitted on the model 146/5 increases the flexibility by eliminating the need for changing bottom punch cam inserts for varying thicknesses of tablets. On the original type 146 machine, both the compression stroke and the ejection stroke are made from one cam, and the compression level is therefore a function of the difference in radius between the compression and the ejection cam inserts. The stepless stroke adjustment, however, makes use of two cams and two levers, one for compression and the other for ejection through the striker and anvil mechanism already mentioned and shown in outline in Fig. 3.

The maximum compression stroke available from the bottom punch cam is 2¼ in., though different inserts can be fitted to give maximum compression strokes up to 3¾ in. The amount of the compression stroke utilised is governed by the position of two gear wheels on the main punch post which act as anvils to transmit the motion of the operating lever to the punch. These have an internal thread and run on a corresponding screwed portion of the main punch post. Thus if both bear against the operating lever the stroke is 2¼ in., but one is set to leave a space of, say, 1 in. between its contact face and the contact face of the lever, the stroke is reduced to 1⅛ in. This is referred to as 1 in. of lost motion, and the condition is illustrated in Fig. 3. The die fill is set by the position of the lower gear wheel and the compression level by the upper gear wheel. The adjustments of the upper gear wheel and the anvil, which last determines the ejection stroke, are linked in such a way that if, for example, the compression stroke is increased, the ejection stroke is decreased by a corresponding amount so that the part is always ejected flush with the top of the die table. Both gear wheels mesh with worm gears which are rotated by means of hand wheels arranged at the side of the machine. Since the adjustment can be made in the initial stages of operation, much setting-up time can be saved.

One of the advantages of using a machine in which the punches are operated by cams is that a greater proportion of the operating cycle can be allowed for feeding the powder to the die than is possible when using machines which have the upper punch operated by an eccentric. On this machine the upper punch can be held out of the die for as much as 110 deg., so that the feed shoe has a longer time to function, making easier the production of thin-walled pieces and pieces requiring deep die-fills. Fig. 1 shows the complete press with guards and feed hopper in position. The adjustment mechanism is shown in detail in Fig. 2.



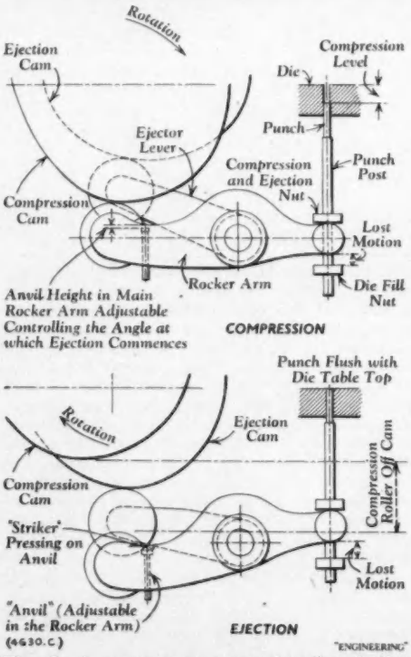


Fig. 3 A separate cam operates the ejection lever, and the adjustment of the anvil, which is linked to the compression stroke adjustment, governs the actual ejection motion.

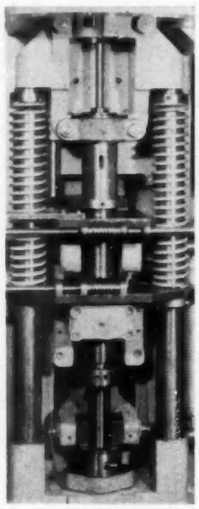


Fig. 1 (left) A feature of the Apex tablet press is the stepless adjustment of the stroke over a wide range. The two hand wheels which control this and also the ejection can be seen at the front.

Fig. 2 (right) Two internally threaded gear wheels act as anvils for the main operating lever. Their position determines the stroke.

An item that can be incorporated in the press is an hydraulic equaliser which can also act as a safety pressure release. It operates on the upper punch with an hydraulic cylinder and, when in use, produces parts of uniform density, whereas a press operated without an equaliser produces parts of uniform dimensions irrespective of any variation in the amount of powder fed to the die. When used as an excess pressure release, the piston in the cylinder moves only when the pressure is higher than the normal operating pressure, as may occur, for example, when excess material has been fed to the die or a foreign substance has entered. In this way it protects both tools and machine. Many variations of the basic model are available, with oversize feed shoes, fine adjustment for very small parts, two telescopic upper punches, delayed feeding and the like. There is also an advance/delay device for producing simultaneous breakaway of multiple punches for flanged parts.

The maximum depth of fill that can be obtained is 6½ in. and the maximum diameter of the piece 3 in. The upper punch has a stroke of 5½ in. with a maximum die entry of 2 in. and the lower compression stroke can be varied from ⅛ in. to 2⅛ in. A variable speed unit is incorporated in the drive, so that the rate of production can be varied from 10 to 45 parts per minute. A combination multiple-disc clutch and brake is also included, operated by a lever from the front of the machine, together with a stop and start button for the motor. For parts having more than one step in them, spring boxes of standard type can be included in the die, which has a maximum diameter of 6 in. The compression level is variable between 4½ in and ⅜ in. and the die fill between 6½ in and ½ in. by means of the stepless stroke adjustment.

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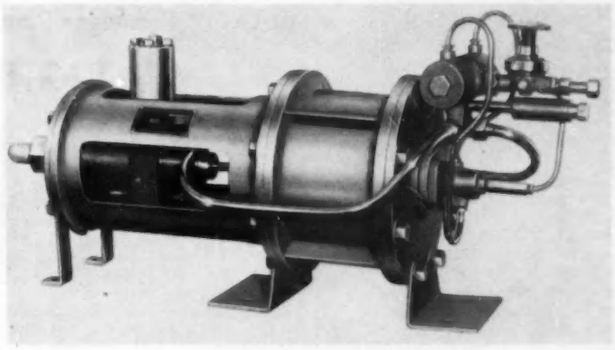
FURNACE BAFFLES

In 1953, Combustion Equipment Limited, 61 Belsize-lane, London, N.W.3, commenced the installation of furnace baffles in the fire tubes of Lancashire and Economic boilers. The aims and objects of these baffles were fully described in ENGINEERING, Vol. 179, page 278, 1955, but, briefly, their purpose is to divert the gas stream in such a way as to give a scouring action, preventing grit and dust being deposited. Experience has shown that their average life is of the order of four years. The firm have therefore decided to increase the guaranteed service life of baffles that they install, from one to two years.

HYDRAULIC PRESSURES UP TO 55,000 LB. PER SQ. IN.

Portable Pump Operated by Low-Pressure Air



Stationary version of Airhydropump which is of the reciprocating type, comprising an air cylinder and piston driving a ram in a hydraulic cylinder.

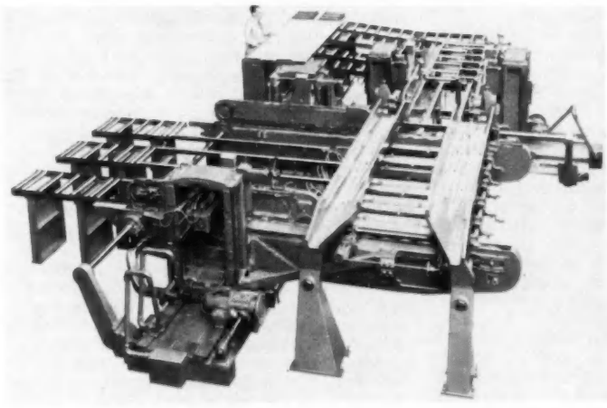
Shown in the accompanying illustration is a new version of the Airhydropump introduced recently by Charles S. Madan and Company, Limited, Vortex Works, Broadheath, Altrincham, for generating hydraulic pressures between 25,000 and 55,000 lb. per sq. in. The pump is of the reciprocating type, comprising an air cylinder and piston driving a ram in a hydraulic cylinder. The air cylinder operates at pressures up to 100 lb. per sq. in. from a normal shop air line; hydraulic pressures below the maximum are obtained by regulating the air supply through an air reducing valve.

The pump has a ratio of 1 to 694, so that, assuming that air at 100 lb. per sq. in. is supplied to the air cylinder, the theoretical hydraulic pressure exerted by the hydraulic ram should be 69,400 lb. per sq. in. In practice, it is naturally found that frictional losses absorb a certain amount of this hydraulic pressure, and the actual pressure obtained varies between 58,000 and 62,000 lb. per sq. in. The pump is therefore recommended for hydraulic pressures up to 55,000 lb. per sq. in.

The air cylinder is double-acting, the air pressure being directed to the top and bottom sides of the piston by means of a change-over valve mechanism. The pump is designed for use with light hydraulic oils, such as Shell Tellus 15 or Shell Tellus 21. The materials of construction are carefully chosen on the basis of considerable experience of high-pressure fluids.

The use of the pump is primarily for the hydraulic testing of high-pressure fittings in the chemical, tube-manufacturing and electrical industries. The pump is also used in certain manufacturing processes where a very small volume of fluid has to be supplied at extreme pressures.

The Airhydropump occupies a floor space of 12½ in. by 44 in. and is 18 in. high. It is available either as the stationary version shown or as a trolley-mounted mobile unit furnished with jack-type steering and incorporating a 5-gallon reservoir.



Based on standard equipment, the Wadkin edge trimmer squares and trims all four edges of a large laminated plastics sheet automatically.

AUTOMATIC EDGE TRIMMING

The addition of roller conveyors and pneumatic handling equipment to two machines which are basically standard in design, has enabled Wadkin Limited, Green Lane Works, Leicester, to provide Bakelite Limited, Birmingham, 11, with an automatic transfer line which trims both edges and both ends of large laminated plastics sheets.

The accompanying illustration shows the layout of the equipment. Sheets are fed directly from the press, and all the operator has to do is to lead them along the roller table terminating at the chain feed of the first trim saw; feed is then automatic. Pneumatic retractable rollers are used to change the direction of travel of the sheet and so bring it on to the feed chain. The trimming is done by twin chain saws based on the Wadkin double-ended tenoner design, and the offcuts are fed via chutes and rollers into troughs above the roller table.

After trimming to the required width between the first pair of saws the sheet continues to travel on power-driven rollers until it makes contact with an electrical trip. It then changes direction and travels at right angles through the second pair of saws, being delivered finally to a roller table, trimmed on all four edges. Just before it reaches the second pair of saws the sheet is squared by pneumatic pressure pads which retract to allow the sheets to pass and then re-set themselves automatically ready for the next one.

The basic design of the machine is applicable to practically any material in sheet form, and equipment could be supplied to deal with sheets up to 16 ft. by 5 ft. or even larger.

INCREASED JIG BORING SPEED AND ACCURACY

The " Hydroptic 6A," a new jig borer and milling machine introduced by the Société Genevoise d'Instruments de Physique, Geneva, Switzerland, incorporates a number of improvements designed to increase output and give greater accuracy compared with the earlier " Hydroptic 6 " model. It has an 8 h.p. spindle-head motor instead of 6 h.p., the diameter of the spindle has been increased from 2·24 in. (57 mm.) to 2·6 in. (66 mm.) and the quill diameter is now 5·31 in. (135 mm.) instead of 4·24 in. (108 mm.). Quill travel has been increased from 10 to 12 in. (250 to 300 mm.), and the quill can be withdrawn completely, so increasing the maximum distance from the spindle nose to the table top by 4 in. (100 mm.). Pre-selective control of the spindle speeds is provided, and the clamping and unclamping of the tools in the spindle is push-button controlled.

Because jig borers are now being used increasingly on production work, the new machine can be provided, if desired, with automatic photo-electric co-ordinate repeating equipment, the information being stored by magnetic drum. Accuracy of repetition is to within 0·00004 in. (0·001 mm.). When machining the first of several workpieces, the operator registers each setting of the table and spindle saddle. This is done by push-button, acting on either of the co-ordinates or on both simultaneously. It is possible to register 20 settings for each co-ordinate, and they can be cancelled singly or collectively. Additional hand settings can be made at any time. Automatic repetition of the settings can be made in both directions along the co-ordinate axes.

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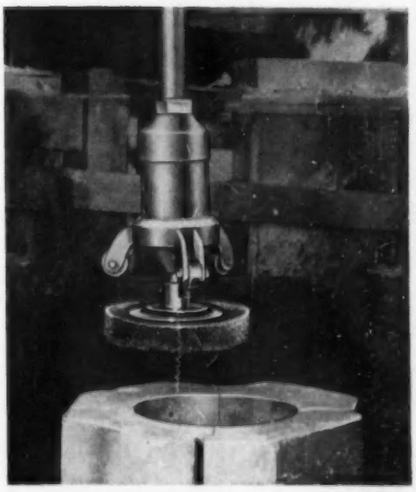
CLEANING BILLET MOULDS IN SITU

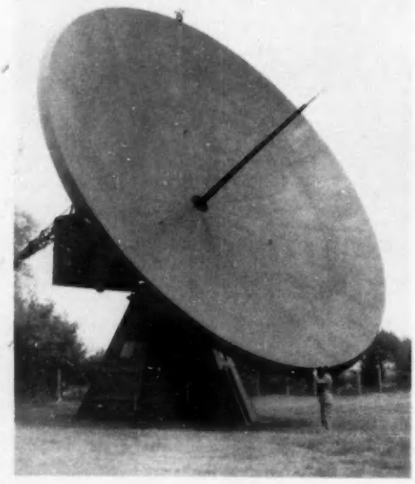
Billet moulds for non-ferrous metals need frequent cleaning to remove the scale which accumulates inside them. To simplify this operation, Flexible Drives (Gilmans) Limited, 195 High-street, Smethwick, 41, Staffordshire, have introduced an air-motor driven rotating brush, which can be suspended over the moulds and lowered into them against a counterweight. Cleaning is thus done in one pass through the mould, which can remain in its normal working position; the need for removing it for hand brushing and scaling is eliminated.

The compressed-air motor exhausts through the tubular handle; scale and dust are drawn in with this exhaust and led through the handle for disposal.

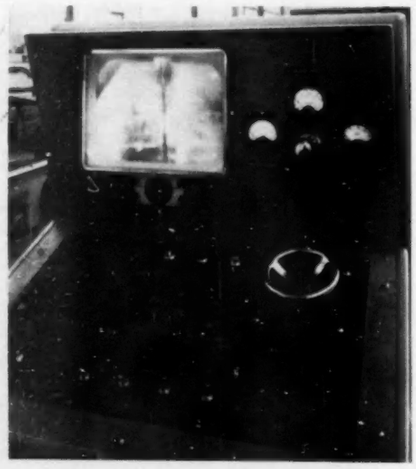


Brushing of billet moulds can be done in one pass by the air-driven brush made by Flexible Drives (Gilmans) Ltd. Scale and dust pass through the tubular handle for disposal.

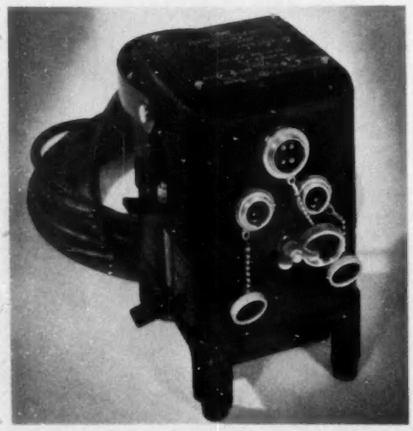
Continuing **Plant and Equipment**



The aluminium reflector of the 45 ft. radio telescope at Malvern has a specified tolerance of ± ¼ in. from a true paraboloid.



The Quasi-Arc internal pipe welding boom incorporates television equipment to enable the weld to be checked continuously and adjustments to be made if necessary. The 14 in. screen is mounted on the control desk.



The new range of lightweight transformers have encapsulated windings and an aluminium alloy casing.

LIGHTWEIGHT RADIO TELESCOPE

The new radio telescope at the Royal Radar Establishment, Malvern, has a 45 ft. diameter paraboloidal reflector. Weighing about 4 tons, the bowl structure and surface skin are made of aluminium alloy. The trunnions are of mild steel. The telescope is for extra-terrestrial observations and micro-wave propagation studies. Normal astronomical equipment aims the reflector. It can turn through one revolution in the horizontal plane and through a half revolution in the vertical plane.

The Establishment specified a tolerance of ± ¼ in. from a true paraboloid. This gave manufacturing tolerances varying from ± $\frac{1}{16}$ in. at the centre to ± ⅛ in. towards the edge—the closer tolerances allow for the worst operating conditions. The accuracy has to be maintained at ambient temperatures varying between 4 and 25 deg. C., and with temperature differentials across the surface reaching 35 deg. C. when part shadowing occurs. Also the accuracy has to be maintained in steady winds of 30 m.p.h.

Ice 2 in. thick, or snow 1 ft. thick, on the upward-facing surfaces does not cause permanent deformation or failure. Steady winds of 60 m.p.h. can be withstood from any direction, and so can 110 m.p.h. gusts lasting 10 seconds.

The reflector was designed jointly by the engineering department of the Establishment, Precision Metal Spinnings (Stratford-on-Avon) Limited, and Messrs. Jenkins and Potter who acted as consultants. Also the Aluminium Development Association gave general advice, and Dr. Whiteman—of the Military Engineering Experimental Establishment, Christchurch—gave advice on riveting. Precision Metal Spinnings fabricated and erected the reflector.

The aluminium alloy used was H10-WP, supplied by the British Aluminium Company, Limited, St. James's-square, London, S.W.1. The alloy was treated with etch primer and an iron oxide undercoat. Finishing coats were green on the back of the assembly and matt black on the reflecting surface.

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WATCHING A WELD WITH TELEVISION

A new internal welding boom, designed and built by Quasi-Arc Limited, Bilston, Staffordshire, incorporates a television camera and screen for viewing the progress of the weld. The boom is used in conjunction with a traversing roller bed, and is designed to accommodate pipes with internal diameters from 17½ in. to 50 in., and up to 28 ft. long. Traverse rates on the roller bed are infinitely variable between 15 in. and 90 in. per minute, and there is a rapid traverse, in either direction, of 20 ft. per minute.

Vertical adjustment of 6 in. is provided, by means of a handwheel and lead screw, on the boom, to allow for various plate thicknesses and the different heights of the bottom of the pipe from ground level. A Unionmelt welding head, suitable for parallel electrode welding, is fixed to the end of the boom, and an angle control sector is provided for positioning the electrode in relation to the seam. Unionmelt flux is carried in a special hopper of 50 lb. capacity, and unfused powder is reclaimed by a continuously rated recovery unit. During welding, the end of the boom is supported by twin spherical rollers, which ride on the inside of the pipe. Twin 150 lb. wire reels are fixed to the boom supporting structure.

In close proximity to the welding nozzle at the end of the boom is a television camera, with a 150 watt photo-flood lamp to provide the necessary light. By means of this camera and a 14 in. monitor screen on the control desk, the operator is given a continuous picture of the welding nozzle pointer in relation to the seam, and adjustments can be made as required to ensure that the weld is located accurately. All the controls are grouped on the desk which carries the television screen; they comprise a camera control unit and controls for the welding heads and roller beds. Welding power is provided by a continuously-rated 1,200 ampere rectifier unit.

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LIGHTER TRANSFORMERS

A range of lightweight transformers that are suitable for industrial users of portable tools have recently been produced by Ferranti's transformer division, Ferry-road, Edinburgh. The company claim that in some instances the saving of weight may amount to almost 50 per cent.

The winding is encapsulated in epoxy resin and the C-core of cold-rolled oriented silicon steel is clamped externally, the whole being assembled in an aluminium alloy casing. Fusing is by means of replaceable cartridge type fuses fitted beneath a cover. Plugs and sockets of standard lightweight aircraft pattern are fitted and a carrying handle is provided. The transformers are designed to be damp-proof, using neoprene gaskets where necessary, and will operate out of doors.

The illustration shows a 750 VA transformer. It weighs 24 lb. and has a maximum loss of 10 watts. The temperature rise is 53 deg. C. and the regulation is 6·5 per cent. maximum.

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INFRA-RED OVEN

An infra-red oven designed for the processing of small articles and materials in batch production has been introduced by the Metropolitan-Vickers Electrical Company, Limited, Trafford-park, Manchester, 17. It consists of a steel sheet casing using infra-red tubular sheathed elements in anodised aluminium reflectors, which are mounted on the top of the oven and heat the material by direct radiation. The sides and floor of the oven are also covered with aluminium sheet to reflect the radiation. The oven is ventilated through louvres in the top cover into the surrounding atmosphere, the air intake vents being in the base, which is raised clear of the bench by small feet. It is also available as a floor-mounting model. The height of the shelf is adjustable. To control the intensity of the radiant heat, a Sunvic energy regulator can be provided, which is designed for separate mounting. The standard oven is rated at six kilowatts nominal, and is suitable for use on three phase 440 volts or single phase 230–250 volts, 50 cycles. Special elements can be supplied for other voltages. Internal dimensions of the oven are approximately 3 ft. by 2 ft. by 1 ft. 6 in. high.

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OVERLOADER ANCILLARIES

Three more attachments are now available for the Merton hydraulic overloader, marketed by McKay Industrial Equipment Limited, Faggs-road, Feltham, Middlesex.

They are an 8 ft. angle-dozer built for angling to 24 deg. on each side; a 20 cwt. crane attachment for direct fixing to the bucket lip by bolts only; and a timber or rock fork which directly replaces the bucket and consists of a 6 ft. wide toothed fork attachment made up of seven T-shaped prongs with a backing plate. There is approximately 9 in. between the teeth, and therefore the fork gives a sieving action during rock forkings. These three items are in addition to the standard attachments already available.

Management

Weekly Survey

Salary Earners on the Increase

It is being increasingly said that the proletariat is fading away and that its place is being taken by a salariat. If such a tendency is true it has wide implications for management, even in the engineering industry. In these days with emphasis by wage earners on security and full employment, together with the fact that their earnings are often at least as high as what may be roughly called comparative grades in clerical work, the substance if not the form of salaried work is becoming increasingly apparent. But, even without this trend, there are signs of a swing over in the labour force from wage earning to salary earning. Since 1948 the number of salary earners employed in manufacturing industry has increased its proportion of the labour force from 16 to 19 per cent.

The trend towards higher incomes is bringing with it a change in the pattern of consumption, many features of which are bound to favour the light engineering industries. As incomes rise and security of job increases a decline in proportion of the increase is observed to be taken by foodstuffs and clothing. A higher proportion is taken in consumer durable goods which covers a vast range of products from motor-cars and television sets to gramophone records and labour-saving devices in the home. To take one isolated example, there were 66½ million gramophone records sold in this country in 1956. A figure of this kind is to-day significant for the electrical engineering industry in a way which would not have been imagined even 20 years ago.

Even in terms of labour relations there is a change on the way for management. An increased desire for leisure, the pressure of a bigger burden of hire-purchase contracts, a greater urge to keep up with the Jones's and an increased application of the security which continuing employment in one job gives may all play increasingly important parts in the complex which adds up to labour's attitude to work and the management hierarchy. These are some of the hints for the future which the national income figures published last week (*National Income and Expenditure* 1957, published by H.M.S.O., price 6*s*.) offer for those who will have to deal with labour in the 1960's.

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Management in the Collieries

The remarks made at the National Coal Board's summer school by Mr. E. H. Browne, chairman of the West Midlands Division of the N.C.B., underlined once again the difficult nature of training for certain types of management. He was speaking about the need to accelerate the revision of the system of management at collieries. The problem which the N.C.B. faces in this matter is well worth studying by management as a whole. There is much more to it than an opportunity for carping criticism of the coal industry.

The introduction of new management techniques and the training of men who will have sufficient faith and imagination to operate them is bound to be slow in the coal industry. Coal managers have been recruited in the past from the coal-mining community (and probably the majority always will be so recruited), which means that they have the loyalties and attitudes of the coal community but also its limitations. This situation applies to all coalfields and therefore affects a complete age group across the industry. The only hope is, therefore, that either a reasonable number of these men will learn the new methods or that the younger generation can be trained into them—an undramatic but inevitable solution.

Few industries offer as varied and complicated management problems as coal mining. On the one hand, under modern conditions, a coal manager is expected to accept responsibility for a larger quantity of capital equipment, involving co-operation with technicians on a bigger scale than ever before, while on the other hand he is faced with a major problem of remote control of his men. Distances are vast underground and the men in the mines build up their own group loyalties which have to be accepted by managers. The problem for the management is, therefore, of reconciling these fierce local loyalties with a flexible, intelligent yet efficient form of managerial control from the office on the surface. Such a specification for a manager is not easy to fill and it will require a high degree of imagination in recruitment and training to find the men to fill the posts.

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Commodities and Primary Producers

Commodities again featured prominently in the news last week, the downward trend in prices being marked by a second cut in copper below £200 a ton. In the early days of 1956, when copper was being sold at well over £400, an inevitable fall was predicted, but few thought the price would break through £200 a ton in the summer of 1957. Copper, of course, has not been alone in the severe downward movement. The price of tin has fallen by some 5 per cent. since September, 1956, and is now hovering uncertainly around £735 per ton. The current price of lead, at about £90 per ton, is over 20 per cent. lower than at this time last year, while zinc has fallen by 19 per cent. to around £73 per ton during the same period. Rubber now stands at 26*d*. per lb., or nearly 3*d*. per lb. below the price in September, 1956. The *Financial Times* index of commodity prices, which has 1952 as the base year, fell from 88·63 to 83·71 between September, 1956, and September, 1957.

The danger in this trend if it goes much further is that the purchasing power of primary producing countries will become affected and this will reduce the exports of the more industrialised countries including the United Kingdom. There is the added complication for the Commonwealth that declining prices for commodities, especially tin and rubber, quickly have an effect on the foreign-exchange earning power of the colonies and dominions. The importing potential of the under-developed countries is still enormous however and, in any case, it would not be long before depression in primary producing countries was quickly transmitted to more highly industrialised markets in western Europe.

Most people are looking to an improvement in the business outlook in the United States and for a reversal of the present trend. Actual production of commodities has not yet run seriously ahead of demand but new and marginal capacity has been opened up and consumers have been running down stocks in anticipation of lower prices. It is these factors which persist in depressing the market. It requires an acceleration in the rate of industrial expansion in America to restore confidence and to justify the bold expansion plans of 1955 and 1956 in certain commodities.

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Free Trade and Full Employment

While the Trades Union Congress was discussing, with favour but without enthusiasm, the proposals for a Free Trade Area and the need to preserve full employment, the same problem was being considered in a rather more academic context at Dublin. Professor J. E. Meade chose as his presidential address to the economic section of the British Association the subject of "The Balance of Payments Problem of a European Free Trade Area." In Professor Meade's opinion, full employment is more important than free trade in Europe and he thinks that European countries should not be forced to abandon full employment policies in case a too hasty liberalisation of trade raises insurmountable balance of payments problems. He would favour certain restrictions on imports even within a free trade area until balance of payments arrangements could be made to work efficiently.

Professor Meade suggests for discussion the formation of a European Monetary Fund into which each member would pay some of its own currency. The management of this fund would buy and sell currencies on its own initiative to ease the balance of payments adjustments of members and it would also keep an eye on the manipulation of exchange rates. He put this forward as a very tentative proposal as a piece of machinery which might help to reconcile the Free Trade Area with full employment.

Few would disagree with Professor Meade's diagnosis of the problem if the Free Trade Area were to be imposed on a Europe which was committed to national economic policies and nothing more. The fact is that the establishment of the European Common Market introduces a vital complication in the analysis. The Treaty of Rome establishing the E.C.M. has little to say about the machinery for overcoming balance of payments difficulties, but it does commit its members to the dismantling of tariffs which must lead to the opening up of marketing opportunities for powerful concerns on the Continent. If the Free Trade Area were held up because full employment could not be guaranteed in British industry, it is quite possible that this country might suffer severe loss of markets in Europe which would lead to something less than full employment while balance of payments problems remain unresolved among the members of the European Common Market. These, in turn, would spill over and have unfortunate repercussions on sterling. Nobody would deny the need to defend full employment but it may not be possible to make its guarantee a *sine qua non* for the Free Trade Area.

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Inquiry on Export Credits

It is 27 years since the Export Credits Guarantee Department was reviewed by a committee. Since this was done by the Niemeyer Committee in 1930 there have been many changes in both the financial and political aspects of international trade. The Niemeyer committee made certain recommendations about E.C.G.D. and over the years since then the Department has operated on commercial principles with a fairly flexible term of reference and method of procedure. A council of business executives outside Government has functioned in advisory capacity. This halfway position between a fully developed Government department and a flexible organisation operating on certain broadly devised principles has worked well on the whole. Its reputation has been for steady plodding rather than speed and brilliance but this probably is inevitable in work of this kind which has official backing.

The President of the Board of Trade has now appointed, in agreement with the Chancellor of the Exchequer, an independent committee to consider the suitability of the present organisation and status of the Export Credits Guarantee Department. The chairman of the committee will be Sir Eric Speed; other members of the committee are Sir Thomas Barnes, Sir Matthew Rysdale and Mr. Bertram Nelson.

The central issue for the committee to decide will be whether the department should move more closely towards the constitution of a formal Government department or whether its individual and flexible status should be reinforced. It is to be hoped that whatever the committee may recommend, the element of flexibility will not be seriously impaired. The E.C.G.D.'s work must be guided by general principles but its efficiency and usefulness depends to a large extent on its ability to judge cases on their merits.

Marketing

ENGINEERING FIRMS IN THE FREE TRADE AREA

9—KLÖCKNER-HUMBOLDT-DEUTZ A.G.

The Diesel engine is playing an increasingly important part as a prime mover in western Europe. Rising industrial production and a higher standard of living have combined to increase substantially the market for Diesel-powered transport and stationary industrial prime movers. The low operating costs of Diesel engines at a time when all fuel prices are rising has given the manufacturers a rapidly expanding market. It has been apparent for a number of years that two important considerations have played an outstanding part in the sale of Diesels. First, there has been the over-riding importance of raising the power/weight ratio. Second, there has been a growing, and at times reluctant, appreciation that after-sales service in its widest aspects is necessary. Customers might forgo an elegant design but they will not be kept waiting for spares.

There are good prospects for the Diesel engine in western Europe in the next few decades if the optimists are proved correct and the level of industrial output continues to rise. Those who move most rapidly towards a higher power/weight ratio and a high quality after-sales service will be in a strong competitive position. Add to these two a competitive standard of technical efficiency and robustness and the prescription for success in the western European Diesel market is complete.

One of the outstanding challengers in this field is Klöckner-Humboldt-Deutz A.G. of Cologne. For some years now, that company has worked hard to associate its name in the minds of engineers with the development of the air-cooled Diesel and good after-sales service. Its challenge is likely to be a strong one in the European Common Market and in the Free Trade Area.

TOP PLACE

Deutz claim to be the largest manufacturers of air-cooled Diesels in the world, although they yield pride of place in total annual production of Diesel engines to F. Perkins Limited, of Peterborough. They make a wide range of engines from 3 to 2,000 h.p. in both air- and water-cooled types. No information is available as to the proportion of engines made for different end uses, but the range includes applications for road and rail vehicles, marine installations, Diesel tractors, locomotives, generating sets and mobile power packs. Taking the company as a whole, Diesel engines accounted for 46 per cent. of total output in 1956. The remaining 54 per cent. was in tractors, commercial vehicles and public service conveyances, Diesel locomotives and such special "Humboldt" products as cement factories and chemical plant and apparatus. On the Deutz side the air-cooled range is between 8 and 275 b.h.p. Last year about 200 air-cooled engines were despatched daily.

In 1956 sales of air-cooled Diesels increased by 52 per cent. As elsewhere there has been a noticeable tendency for the average horse-power to increase. In 1938 the average horse-power per engine was 26·8; it was 48·2 in 1954/55 and 50·4 in 1955/56. It is noticeable that the sale of slow-running high-power Diesel engines seems to have been increasing both in home and export markets more quickly than engines with a high rating in revolutions per minute. This follows the trend which has been noticeable in this country in certain types of Diesels. It has been estimated by one source that between 1952 and 1955 the output of German Diesels up to 30 h.p. increased by 56 per cent., while the weight increase went up by only 4·4 per cent.; between 30 and 200 h.p. the weight increased by 6·5 per cent. The total horse power output however went up by 51 per cent.

The Germans have naturally made the most of such statistics. They have claimed that there have been important changes in the design and construction of German Diesels since the war. They have emphasised what are claimed to be important combustion changes, better materials, ability to use higher quality fuels and lubricants economically, and thermostatic control of cooling. They have had all along, of course, the advantage of the German tradition in C.I. engine construction from Diesel himself. These German claims do not go unchallenged, and British manufacturers can offer equally impressive improvements and, indeed, on some technical developments British Diesels are known to be outstanding. Nevertheless, the British Diesel-engine industry has to take account of a growing and successful sales challenge from the German industry of which Deutz is an outstanding member. Table I sets out the German export challenge in the last three years.

Comparing these three years the value of German exports went up by 37 per cent., while British exports showed an increase of 47 per cent. German Diesels did very much better, measured by a percentage increase, than British exports for use in motor vehicles but not nearly so well in marine and stationary applications. It will be interesting to see what has happened in the first half of 1957. The value of United Kingdom Diesel exports was down on the first half of this year (again excluding parts) by 1·3 per cent., but German figures are not yet available. The inclusion of parts would substantially alter the figures but there is no reason to think that they would alter the picture of the two countries relative to each other.

MARKET SIGNIFICANCE

For the purposes of the Free Trade Area, however, total exports are not a very reliable guide to export potential. A significant proportion of United Kingdom exports goes to the Commonwealth, although France, Belgium and the Netherlands are important markets. In the case of Germany, the biggest market for Diesel engines for motor vehicles in 1956 was France. The largest market for marine Diesel engines was Holland and the largest market for stationary Diesel installations was India, with S. America and W. Europe close behind. As would be expected, therefore, the German stake in the western European market is very substantial and, judged by recent export performance, they probably fight the United Kingdom there on something like equal terms. They may indeed have the edge on us.

It will be noticed from Table I that the composition of German and United Kingdom exports is rather different. This follows to some extent from the difference in the geographical pattern, but it is worth noting that although stationary Diesels are equally important to each country as a proportion of total exports, motor vehicles are much more important to this country than to Germany, and marine applications are much more important to Germany than to the United Kingdom. This is bound to have an effect on the scale of production of different horse powers as each country faces an era of increased economic integration in western Europe.

For what it is worth, the geographical pattern must be favourable to Germany compared with the United Kingdom as the European Common Market and Free Trade Area come into existence. It may be, indeed, that in terms of tactics for the Free Trade Area the proportionately larger share of exports going into the European market from Germany will just about make up the overall advantage which the United Kingdom has in the export market as a whole. If this is anywhere near the facts of the case the German Diesel industry will gain from the establishment of the Free Trade Area at the expense of Britain if the Free Trade Area is long delayed. The dismantling of tariffs among the signatories of the Treaty of Rome will strengthen Germany's position in a market where it is already a powerful competitor, while British engines are excluded from tariff-free treatment until the Free Trade Area becomes a reality.

TARIFFS AND HOME THRUSTS

The tariff on internal combustion engines coming into this country is levied under the Import Duties Act, 1932, and is at present 21 per cent. In the last few years the importation of marine engines (petrol engines cannot be differentiated from Diesel engines) has fallen off considerably and so have most other types of internal combustion engines. The notable exception is the trade in engines for motor vehicles which, along with parts, increased from about £385,000 in 1954 to £1,170,000 in 1956. To judge from the 1956 figures the total import market for Diesel engines and spares is worth about £3 million a year. A market of this size taken in conjunction with a fairly heavy tariff suggests that the foreign Diesel-engine industry, of which the German section is the most important part, already has a useful bridgehead in this country. From time to time German concerns obtain substantial orders both from private companies and from the nationalised industries, and the elimination of tariffs might increase the threat of German competition in this country.

On the other hand this threat should not be over-emphasised. The British industry has already made a significant thrust into the German home market. It has been estimated that 75 per cent. of the Diesel engines imported into Germany are British. F. Perkins Limited, for example, are firmly established in the German market. Leading combine manufacturers in Germany, such as Gebr. Claas G.m.b.H. and Heinrich Lanz A.G. along with J. Dechentreiter G.m.b.H., are fitting Perkins' Diesels to their equipment,

TABLE I.—*United Kingdom and German Exports of Diesel Engines (excluding Parts)*
£000

	1954		1955		1956	
	United Kingdom	Germany	United Kingdom	Germany	United Kingdom	Germany
Diesels for motor vehicles	6,372	2,010	8,642	3,000	11,190	4,570
Diesels for marine propulsion	3,518	5,840	4,341	6,540	5,385	7,640
Stationary Diesels	11,114	7,670	12,422	7,900	14,182	9,160
Total	21,004	15,520	25,405	17,440	30,757	21,370

TABLE II.—*Per cent.* ad valorem *Tariff on Internal Combustion Engines*

Benelux	Denmark	France	Germany	Italy	Norway	Sweden	United Kingdom
9	4	22	20	32	11	13	21

and the British company now has six service stations equipped with £2,000 worth of spares each. According to the export sales manager of Perkins, three of these centres are private concerns and the others are farmers' co-operatives. This company considers the German territory an important area for sales development and has increased its exports to it from 310 units in 1954 to 1,948 units in 1956. Up to April in 1957 some 1,500 engines had been sent there.

The strength of British competition in the home of the Diesel engine (a competition which the Germans admit since Deutz, with a faintly Teutonic absence of humour, claim that they are nearly as big as Perkins) illustrates what may be a highly important general point for the Free Trade Area. Here is a concrete case where the Free Trade Area may well lead to an exchange of highly developed engineering products between heavily industrialised communities. Germany and the United Kingdom may yet stimulate each other's markets by a mutual exchange of highly competitive engineering products. The reason for this is not far to seek. The Germans, for example, know something good in Diesels when they see it and they will buy—if the after-sales service is adequate.

One of the large question marks hanging over both the European Common Market and the Free Trade Area is the effect of " harmonisation " of wages. This word " harmonisation " refers to a clause in the Treaty of Rome establishing the European Common Market and calling for a gradual process of wage adjustments and social insurance payments in the participating countries so that there is no acute price competition arising out of wage differentials. This clause was inserted into the Treaty of Rome, at the insistence of the French supported by the Belgians. The tendency will probably be for the wages and social service payments in the low-wage countries to move upward to the higher level. Under such circumstances German wages would also rise, although it is not clear by how much.

According to the latest annual report of Klöckner-Humboldt-Deutz their turnover in the financial year 1955-56 was 736 million Dm. Of this, wages and salaries accounted for 135 million Dm., which gives a ratio of wages and salaries to turnover of just over 18 per cent. (which is a similar figure to Perkins'). It would therefore appear that the question of tariffs is much more important to the German Diesel industry than the " harmonisation " of wages. By a coincidence, the level of the United Kingdom tariff at 21 per cent. is slightly higher than the total cost of German wages and salaries as a percentage of turnover. The tariff position for internal combustion engines in all western European countries is given in Table II.

The Italian tariff is particularly high but does not apply in all cases. It will be noticed that the German industry has experienced no great difficulty in surmounting the French tariff of 22 per cent. as well as establishing a strong position in Benelux and Sweden. Germany itself imposes a fairly heavy tariff at 20 per cent. and the effect of tariff disarmament between Britain and Germany will obviously be mainly a question of two imposts cancelling each other out.

NO STRAIGHT FIGHT

The question of competition in Diesels in the Free Trade Area is, of course, far from being a straightforward fight between leading German and British manufacturers. It is apparent that air-cooled Diesels, in which Deutz claim with some justification an important tactical advantage, are going to become increasingly important in the European market. Leading contenders for the market in this country have recently announced new or extended ranges of air-cooled types. Petters Limited announced a new range early this summer and so did Ruston and Hornsby Limited. References were made by the chairman of R. A. Lister and Company, Limited, to the success of their new air-cooled types at the beginning of this year. These developments have been accompanied also by increased price competition. Last autumn R. A. Lister and Company, Limited, announced reduced prices for their engines against the chronic upward trend of costs, and Henry Meadows Limited did the same at the beginning of 1957.

But any impression of a straight fight across old-fashioned national frontiers has to be modified by the increasingly complicated licensing systems which operate. To go back only to the recent past, the Brush Group Limited last year acquired the rights to make the German Maybach engines and shortly afterwards Armstrong Siddeley Motors Limited acquired the manufacturing rights in this country of the Dutch Werkspoor Diesels. To some extent also the future of the Diesel is complicated by the rapid development of the Pescara free-piston engine, where the original manufacturing rights are in France. By the middle of this year no fewer than seven licensees had been appointed to make the Pescara in this country alone—a development which has taken place within the last year or so. It is generally thought that the Pescara type of engine will offer serious competition to the heavy Diesel once the overall market for internal combustion engines has stopped expanding.

Meanwhile, the German Diesel manufacturers, among whom Klöckner-Humboldt-Deutz are outstanding, offer a serious challenge in the European market. There is little evidence to suggest, however, that it cannot be satisfactorily met by British engines once their manufacturers realise that the European market must be actively developed—and serviced.

Research and Development

PROGRESS IN ARTIFICIAL RAIN-MAKING

One of the two principal mechanisms of rain formation relies on the upper clouds consisting of tiny water droplets which remain liquid at temperatures far below zero degrees Centigrade. These supercooled droplets freeze only if they become affected by minute particles—ice nuclei—after which they grow rapidly into ice crystals; such crystals may then combine, fall and melt, and descend as a raindrop. These stages in the formation of rain are being studied at Imperial College and were described by Dr. B. J. Mason during a symposium on rain-making at the Dublin meeting of the British Association. He described how water of a high degree of purity in raindrop size had been supercooled in the absence of foreign particles to − 35 deg. C. before freezing occured.

The nature and origin of the ice nuclei which are essential to initiate freezing at higher temperatures than this are still uncertain. They probably consist, suggested Dr. Mason, of rare dust particles carried up from the earth below rather than of meteoritic dust entering the atmosphere from without. Indeed he has demonstrated that certain particles of clay minerals act as very efficient ice nuclei, while finely powdered meteor dust is apparently inactive. Moreover these clay particles " improved " at the second attempt: thus, after forming ice crystals at high levels, the crystals evaporated and the particles fell to lower clouds which were " seeded " at considerably higher temperatures than they could be by particles coming up directly from the earth. Another process which accelerated ice-crystal formation had also been observed. Water droplets of 0·0001 in. across often exploded on freezing to produce many tiny ice splinters, each of which grew rapidly and multiplied the ice crystals present by a kind of chain reaction.

Though in Britain rain was formed by the ice-crystal process, it was also known that showers sometimes fell from clouds containing no ice. The rain was apparently then formed by a few relatively large cloud droplets sweeping up their smaller neighbours. Dr. Mason thought that these larger droplets probably came from ocean spray, but for regions remote from the sea it was necessary to look for another cause.

Measurements of the physical processes underlying cloud and rain formation are being made by the Meteorological Research Flight at Farnborough and an account of this work was given by Mr. R. J. Murgatroyd. Condensation nuclei are counted using a photoelectric device and freezing nuclei by a cold chamber; salt particles in the atmosphere are caught by impaction techniques and identified chemically, cloud droplets are caught on an oiled slide to be photomicrographed, and raindrops are counted and sized by the indentations they make on a thin aluminium foil.

Measurements of the concentration of condensation nuclei show that they are ten times more plentiful over the land than over the sea and that industrial pollution greatly increases their number. Cloud droplets are found in concentrations which are only a fraction (one-tenth) of the condensation nuclei and raindrops are found only one for about every 1,000 c.c., there being about 100,000 cloud droplets for every raindrop. By measuring the sizes of the larger cloud droplets in small clouds, the beginnings of rain formation can be traced and by measuring raindrop size at different altitudes the development of the rain spectrum can be determined. Similarly the concentrations of ice crystals and supercooled droplets can be studied and their contribution to the rainfall distribution can be followed by sampling at different altitudes. It has been demonstrated by the M.R.F. that it is fairly easy to modify suitable clouds under favourable conditions and the distribution of various cloud particles has been mapped by making use of airborne radar.

In the third paper of the symposium, Mr. W. Machlin outlined the cloud-seeding or rain-making experiments that have been carried out in Australia during the last ten years. Australia with its large arid and semi-arid regions, and with an economy relying to a great extent on such primary products as wheat and wool, is a country which would benefit particularly from even a moderate control of natural precipitation.

Two methods of seeding have been examined. One, based on an American discovery, uses dry ice, but this was found to be prohibitively expensive. On the other hand, silver iodide has been successfully and (economically) used and details were given in the paper of the techniques of application and the concentrations used. One difficulty of long-range seeding is that of discovering suitable clouds for the movement during the gestation period to take the clouds over the target area.

Two techniques have been developed for determining whether changes in precipitation are affected by the seeding. The first compares the conditions and rainfall in a " control " area adjacent to those in the seeded area, but there must necessarily be a large number of uncertainties in such a comparison. The second relies on seeding being confined to random periods so that the intervening unseeded periods are available to provide control data. It has the particular merit that a cover of rain gauges can be specially installed and maintained for the purpose of the tests. The results so far indicate that the ratio of the target to the control area precipitation has been greater during the seeded periods. At present, however, it is not possible to say with full confidence whether this is a natural effect or whether the seeding programme was responsible but it is proposed to continue the experiments, using the same techniques, until a firm answer to this question can be given.

Continuing **Research and Development**

ENERGY AND POWER SUPPLY*

By Sir Josiah Eccles

Concluded from page 344, *September* 13

The fuel savings that will accrue from the improved thermal performance of generating plant, although substantial, will not be sufficient to make good the deficit in available coal supplies, and the gap must be filled by imported fuels or by nuclear energy.

The Central Electricity Authority have made arrangements for 15 of their power stations to burn fuel oil instead of coal and this will save about 8 million tons of coal annually by 1960. These stations are remote from coalfields and on the coast where berth facilities are available, or near oil refineries from which the oil can be supplied by pipeline. However, oil burning is essentially a stop-gap measure and the long-term substitute for coal must be nuclear energy.

III—NUCLEAR

A good deal has been said and written about the harnessing of nuclear energy, but perhaps it might be useful if I were to repeat here some of the fundamentals. As Einstein has shown, matter and energy are interchangeable and it has been calculated that the annihilation of 1 lb. of matter would release energy equivalent to 11,340 million kWh of electricity. If such conversion were possible the whole of the electricity requirements of Great Britain during the present year would be obtained from about 7 lb. of matter.

However, only a small fraction of the energy of the nucleus of some atoms can be released, either by splitting the nucleus and forming two or more smaller nuclei with a lower energy content, or by fusing two or more nuclei into one larger nucleus having a lower energy content.

To produce effective power from nuclear fission it is necessary to bring enough U 235 into close proximity and when this is done there are two additional phenomena which greatly facilitate the process. The first is that when the ratio of the volume of uranium 235 to the area of its surface envelope is above a certain critical value the chance of one fission triggering off another fission by neutron bombardment is very great. The conditions suitable for a chain reaction can thus be established.

The second phenomenon is that if fission takes place in the presence of certain other non-fissile atoms (U 238 and thorium 232) it is possible to transmute them into elements which are themselves fissile and thereby create additional nuclear fuel. Indeed the problem of the future may well be so to arrange our affairs that the scarce, precious U 235 is used to a minimum extent and then only to produce a greater quantity of its offspring. When mated with U 238 it produces plutonium and with thorium it produces U 233.

The fusion of hydrogen atoms to produce helium releases energy. The energy release per helium atom produced is considerably greater than that released per uranium fission. Unfortunately, the temperature at which fusion takes place is so high that no known material would withstand it in the solid state. Electromagnetic means to induce fusion at manageable temperatures are being tried but success has not yet been reported.

Uranium and thorium are therefore the sources of nuclear energy which are used at the present time. They are both widely distributed in the earth's crust but the concentration is very small, estimated at 0·0003 per cent., for uranium and double that amount for thorium. More concentrated deposits of uranium ore are to be found in several parts of the world, but concentrated thorium ores tend to be less abundant. If natural uranium, which contains only 0·7 per cent. of U 235, is used, the volume of fuel required to achieve a critical condition is large. On the other hand, if uranium highly enriched in its U 235 content is used, a much smaller volume of fuel is necessary to achieve criticality.

Two other nuclear considerations are important. First, the materials other than fuel in the reactor must not absorb neutrons to any appreciable extent otherwise the reaction will tend to peter out; and, secondly, in a thermal reactor the moderator must be capable of slowing down neutron speeds to 2 to 3 miles per second, at which speed they are most effective in producing further fissions. The energy released appears as heat and this must be conducted from the reactor and used to produce mechanical power.

* Paper read before Section G of the British Association at Dublin, on September 5, 1957.

ELECTRICAL PROGRAMME

In February, 1955, the Government issued a White Paper which outlined a proposed programme for the application of nuclear power to the electricity supply system of Great Britain. The programme envisaged the construction of 12 stations by 1965 having an output capacity of 1,500-2,000 megawatts.

Because of the increasing burden of fuel imports on the balance of payments, and in the light of advances in nuclear technology, the Government, in conjunction with the Electricity Authorities and the Atomic Energy Authority, announced in March of this year a trebling of the earlier programme. The present programme therefore is to bring 5,000-6,000 MW of plant into operation by the end of 1965.

An important factor in deciding to adopt the gas-cooled graphite-moderated reactor, was that it requires only natural uranium. We have had a number of years' operating experience with this type of fuel and, as the strain on our conventional fuel resources had to be relieved at an early date, this was the only type of reactor which could be considered as a current commercial proposition.

Already one station of this type is in operation at Calder Hall and the Central Electricity Authority have placed orders for two commercial power stations which will use the same type of reactor. These stations are already under construction at Bradwell in Essex and Berkeley in Gloucestershire, and will have output capacities of 300 MW and 275 MW respectively. They are programmed to come into operation in 1961. Fig. 6 shows the progress of construction work at the Berkeley site. Work has also begun during the last few days on the station for the South of Scotland Electricity Board at Hunterston in Ayrshire; it will have an output capacity of 360 MW

Work will also be begun soon on an additional station at Hinkley Point in Somerset. Permission will be sought to site further stations in the country. The Bradwell and Berkeley stations will each have two carbon-dioxide gas-cooled, graphite-moderated reactors, developments of the Calder Hall prototype, but varying in detailed design at each site.

GAS-COOLED GRAPHITE-MODERATED REACTORS

The accompanying table gives details of a typical gas-cooled graphite-moderated reactor and, whilst not referring to any particular one, the information is representative of the reactors to be employed in the first nuclear power stations.

The heart of the reactor is the graphite core through which the fuel is distributed and which slows down the neutrons to thermal energies. The graphite structure with a nominal diameter of 50 ft. and a height of 30 ft., is built up from many thousands of accurately machined blocks of high quality material. The core weighs about 2,000 tons and must be supported in such a way that the stack remains stable in spite of temperature and irradiation effects.

Typical Characteristics of Gas-Cooled Graphite-Moderated Reactor

Number of channels	3,000
Total weight of uranium per reactor	250 tonnes
Maximum fuel temperature	580 deg. C. (1,080 deg. F.)
Maximum can surface temperature	425 deg. C. (800 deg. F.)
Height of graphite structure	30 ft.
Nominal diameter of graphite structure	50 ft.
Total weight of machined graphite	2,000 tons
Diameter of pressure vessel (spherical)	70 ft.
Vessel wall thickness	3 in.
Thickness of concrete biological shield	9 ft.
Number of control rods	150
Charge facilities	Charge and discharge carried out, under pressure + load
Diameter of main ducts	5 ft.
Reactor inlet pressure	130 lb. per sq. in.
Reactor outlet pressure	125 lb. per sq. in.
Horse-power per blower	3,000
Number of blowers per reactor	6
Number of heat exchangers per reactor	6
Gas temperature at reactor inlet	180 deg. C. (360 deg. F.)
Bulk gas temperature at reactor outlet	380 deg. C. (720 deg. F.)
Reactor heat output	525 MW
Net electrical output	140 MW

Fig. 6 Construction work in progress at the Berkeley nuclear power station.

The fuel elements are fabricated from natural uranium into rods which have a diameter of a little over 1 in., and are sealed in metal cans to protect the uranium from attack by the cooling gases and to prevent the poisonous fission products escaping into the gas circuit. The fuel elements are inserted in a large number of vertical channels formed in the core, and the heat liberated by the fission process is removed by the cooling gas, which enters at the bottom of the core and flows upwards through the channels.

As the amount of power required to circulate the gas through the reactor, heat exchangers and interconnecting pipework varies inversely as the square of the gas pressure, the highest practical pressure must be used. This means that the reactor has to be enclosed in a large pressure vessel the diameter of which is determined by the size of the core, this in turn being fixed by nuclear considerations. The gas pressure is made as high as practicable having regard to the difficulties of site fabrication and the welding of large vessels. The maximum thickness of steel plate used at present is 3 in.

The heated gas leaves the reactor at a temperature of about 700 deg. F. and is circulated by blowers to the associated heat exchangers. Here the gas gives

up its heat to generate steam which is used in turbines to drive electric generators in the usual way.

The temperature of the gas leaving the reactor determines the maximum steam temperature, but other factors are taken into consideration in the final selection of the most economic overall design. An interesting development has taken place in the arrangement of the steam cycle. Instead of producing steam at one pressure as in a conventional boiler, the heat exchangers each have two separate sets of steam-raising tubes. A proportion of the steam fed to the turbine is generated at a much higher pressure than could be considered for a single-pressure cycle, and the remainder is generated at a low pressure and injected into the appropriate stage of the turbine.

By this means it is possible to make better use of the heat available from the reactor for a given gas flow, thus increasing the efficiency of the cycle as compared with a single-pressure cycle. Theoretically, a triple-pressure cycle would give a better performance, but this development was rejected when the increase in performance was set against the additional complication and cost.

Control of reactivity of the core is obtained by inserting a number of boron-steel rods into the core through branch pipes in the pressure vessel. Branch pipes are also provided for the fuel-element channels so that the fuel can be charged and discharged whilst the reactor is on full load and at pressure.

The intense reactivity in the core must be shielded so that the radiation level in working areas is safe for plant operators. This is accomplished by surrounding the reactor with a dense concrete " biological " shield having a thickness of about 9 ft. Fig. 7 shows a cross-section through one of the reactors to be constructed at the Bradwell nuclear power station.

When the nuclear power stations have been in operation for some time there will be sufficient fissile material available to enrich fuel for use in more advanced designs of reactors. Enrichment of the fuel will allow the size of the core to be reduced, and the use of liquid coolants could increase the permissible upper limit of operating temperature thus improving the thermal efficiency.

Costs

The cost of electricity generated at nuclear power stations will largely depend on the capital cost of the plant, life of the station, and the net cost and degree of " burn-up " of the fuel.

At present the capital cost of nuclear power stations is 2½ to 3 times that of a conventionally fired station of the same electrical output, but the fuel costs will be lower. This means that the stations must be run at full output for as much of the time as possible, i.e. at the highest load factor, in order to spread the costs over the greatest output. Based on experience with conventional stations it is thought that a load factor of 75 per cent. and a life of 20 years are reasonable assumptions.

The initial fuel charge is most conveniently considered as a part of the initial capital investment, and because it is continuously replenished, attracts interest charges only. The fuel replacement cost will depend on the length of time that the fuel can usefully remain in the reactor, and it is hoped that an irradiation level (i.e. heat output) of 3,000 megawatt-days per tonne can be achieved.

Based on these assumptions, the cost of nuclear power from the first stations will probably be between 0·6 and 0·7 pence per unit, which is slightly more expensive than electricity generated by modern coal-fired plant.

Looking ahead, one can foresee a continuing improvement in the performance and output of the gas-cooled graphite-moderated reactor. In particular, fuel-element temperatures are likely to be increased and so thermal efficiency and output will increase. It is possible that the next contracts placed will be for stations having an output capacity of 500 MW, and perhaps even higher, so that fewer sites will be required to meet the enlarged programme.

Siting Problems

Because of the large amounts of cooling water required, suitable sites are limited mainly to those around the coast and on estuaries. In recent times the siting of any kind of power station has become progressively more difficult because increasingly extensive facilities are needed. The best sites have already been developed and there is natural disquiet over the spread of industrial development to rural areas. Nevertheless, in order to implement the nuclear power programme, power stations and high voltage transmission lines may have to be located in areas hitherto untouched by industrialisation. If Britain is to have the power needed for the industrial expansion necessary to enable its people to enjoy a good standard of living, we must find a way to fit the nuclear installations into our countryside, holding a just balance between some interference with existing amenities and the provision of electricity, which itself is perhaps one of the greatest amenities of western civilisation.

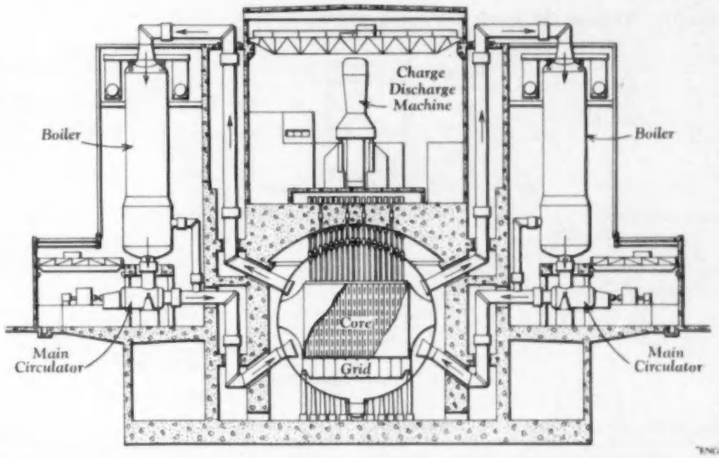

Fig. 7 Cross-section through one of the reactor buildings for the Bradwell nuclear power station.

IV—FUTURE DEVELOPMENTS

To end this brief review of the pattern of development in Britain, reference should perhaps be made to some innovations which may feature in the future operation of the British electricity supply system.

UNDERGROUND GASIFICATION

The National Coal Board estimates that there are more than 300 million tons of coal in the U.K. which are uneconomical to mine by conventional means. This coal has an impermeable overburden such as clay or shale and lies between 100 and 600 ft. deep in seams not less than 2 ft. 6 in. thick which are level or do not slope more than 1 in 5. If sloping, thin and very deep seams are added, the total potential tonnage is likely to be well over 500 million tons. This coal is suitable for gasification and, in total, is probably sufficient to generate about 1,000 MW continuously for 50 years.

" Underground gasification " is a process for converting coal in the ground into gas for use in generating electricity. There is no new problem in gaining access from the surface to the coal seam by means of boreholes or shafts whereby air can be passed through a burning coal seam and the gas brought to the surface. The creation of a channel through the coal in which the reaction can be maintained is new, however, and it is largely the cost of this channel and the amount of usable gas which can be produced from it which determines whether or not the gas can be made available sufficiently cheaply for the generation of electricity.

The process may be of the " open " or " blind " borehole variety: in the former, the air is blown in through one borehole and the gas produced extracted from another; in the latter the air and gas are conveyed in and out of the same borehole.

Experimental work to ascertain whether a practical and economic process of underground gasification could be developed was begun in 1949 and a report on the six years of development was published in 1956 by the Ministry of Fuel and Power. The report mentioned that gas derived from burning coal underground might be produced at 2*d.* or 3*d.* a therm compared with the then average cost of power station coal of 3·3*d.* per therm.

Much more experimental information is required and to this end a pilot scheme able to generate about 5 MW is being undertaken jointly by the C.E.A. and the National Coal Board. It is hoped that operating experience with this plant will allow larger scale installations to be planned and costed with confidence.

PUMPED-WATER STORAGE

The idea underlying pumped-storage schemes is not new: in fact, such plants have been in operation in Europe for many years, one having been installed at Zurich some 70 years ago. In Britain the only plant of this type to be installed so far is a small unit commissioned in 1918 on the River Tweed, serving certain mills. However, the severe restrictions in recent years on capital available for new construction have served to focus attention anew on pumped storage as a possible means of conserving capital. Whether pumped storage is economically worth while compared with exploitation of the country's alternative assets is a question which has to be answered in each case. After exhaustive investigation of possible sites the Central Electricity Authority have approved a scheme to commission a 300 MW pumped-storage installation at Blaenau Ffestiniog in North Wales, and are satisfied that the scheme will prove economically sound. It is hoped that this installation will be in operation by 1960.

The principal economic function of pumped storage is to provide an addition to the output capacity of the generating system when it is most required—that is, at times of peak loads. This is achieved by utilising off-peak electricity to pump water from a river or low-lying reservoir to an elevated storage basin from where it is subsequently returned to drive conventional hydro-electric generating plant at times of peak. Fig. 8 shows a typical arrangement.

Where the pumping energy is supplied by thermal or nuclear stations, as will probably always be the case in Britain, the operating cycle results in the consumption of off-peak electricity generated by the higher efficiency plant, which would otherwise be closed down or run lightly loaded during periods of low system demand, and its " reconversion " into high-value electricity at times when generation by thermal plant is less economical, due to the costly running of the older, low-efficiency plant to meet the system demand. It is important to remember that we are not getting something for nothing, rather there are appreciable conversion losses. The annual overall efficiency of the Ffestiniog scheme is expected to be about 75 per cent.

To provide for emergency outages and sudden increases in demand, it is normal practice in thermal systems to maintain a certain reserve of generating capacity known as the " running spare." Also, in certain stations, it may be considered uneconomic to shut down steam plant for less than a predetermined number of hours, with a resulting increase in the amount of " running spare " carried during those hours. In contrast, hydro plants can be started up and shut down very quickly, and can deal with large fluctuations of load more rapidly than steam-operated plant. For this reason, and because hydro plant breakdowns are relatively few in number, well-planned operation of hydro plant in a combined thermal and hydro system enables the capacity of thermal " running spare " to be reduced.

By their very nature pumped-storage schemes will generally be remote from the load centres and it is to be expected that the transmission costs will be higher than in the case of steam stations. In addition, the transmission costs in respect of pumping energy must be taken into account.

Whether a pumped-storage installation would be economically justifiable in a given situation is a question which, in the last analysis, depends upon the intrinsic features of the site itself and its location. The storage capacity and head available, inflow if any, length of pipelines, amount of civil works required, availability of local stone for dams, availability of local labour, the position of the site relative to load centre and to a source of pumping energy are all factors which will affect the economic merit of any given project.

Unhappily, it seems that there are relatively few sites which would meet all the technical requirements and remain immune from objections on amenity

Continuing Research and Development

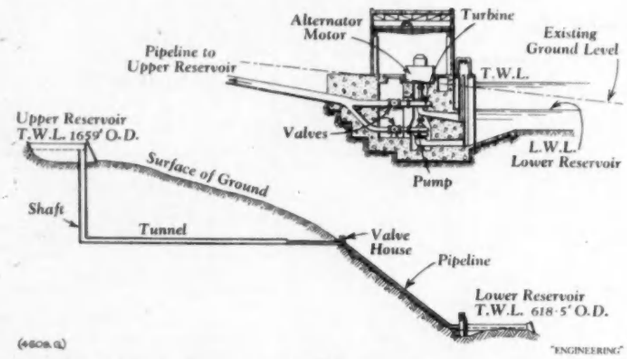

Fig. 8 Typical arrangement for a pumped-water storage scheme.

grounds. There is no question but that pumped storage in conjunction with conventional steam, hydro and nuclear plant is a very desirable operational facility in a co-ordinated system of supply such as now exists in Britain. Nevertheless, enthusiasm for the principle as representing at least a partial solution of the peak-load problem must be tempered with economic realism.

CROSS-CHANNEL CABLE

It has long been recognised that the provision of a link between the supply systems of France and Britain would offer mutual advantages in the pooling of generating plant to effect economic transfers of energy and in saving the capital cost of installing a certain amount of plant in each country. There has been in existence for some years a joint Cross Channel Interconnection Study Committee of the English and French electricity authorities which, in 1955, reported upon a development programme embarked on earlier with the approval of both countries. The programme was based on a projected 132 kV alternating-current connection consisting of four submarine cables, one of which was to be a spare, and included some sea trials off the coast near Dover and deep-water trials off the Carnot Jetty at Boulogne.

The operational problems inherent in the a.c. interconnection were obvious. Although the frequency of the supply systems in the two countries is the same (50 c/s), fluctuations would be inevitable and, to avoid the possibility of involuntary load transfer, the installation of costly automatic frequency control equipment would be required in England. The equipment is already provided on the Continent.

In their initial investigations, the Study Committee did not overlook the advantages of a high voltage d.c. connection, both in cable design and operation, but they felt that further development of this type of transmission was desirable before it could be considered technically sound. The merit of d.c. operation lies in the facility it offers to interconnected systems to control their frequencies independently, resulting in greater precision in regulating load transfers than would be possible with an a.c. connection. Moreover, the flow and return paths for the energy interchange can be provided, arranged either side by side or concentrically, within one length of cable, instead of in the four cables necessary for the a.c. scheme. On the other hand, rectifying plant is required at each end to convert from a.c. to d.c. and vice versa, and it is not possible to transmit reactive MVA over the d.c. link.

Following the earlier investigations, a study of recent experience with a high-voltage d.c. submarine cable interconnection between Sweden and Gotland led the Committee to recommend the substitution of a d.c. scheme for the a.c. scheme which they had already devised. Their proposals provide for a single circuit d.c. connection between a point on the 275 kV system in England, at Dungeness, and a point on the French 225 kV system at Le Portel near Boulogne. The interconnection capacity will be 160 MW at a nominal voltage of 200 kV.

Subsequent to the decision to employ d.c. the English and French authorities drew up a revised specification for the submarine cable and issued it to competitive tender. Whereas the type of cable previously considered (for use with a.c. but suitable for later adaptation, if necessary, to d.c.) restricted the construction to a gas-filled type, with a cable designed for d.c. only it was possible to seek tenders for a variety of different constructions including, for example, single, twin or concentric conductors, either solid or gas filled, and perhaps using plastics insulation. Accordingly, the specification was drawn very widely, stating only the voltage and current-carrying capacity, the type of cable to be offered being left to the tenderer.

Apart from overall protection on the transformers and back-up over-current protection at the two ends no protection would need to be provided other than the apparatus to suppress the d.c. transmission by grid control under fault conditions. It would appear that the greatest hazard likely to be experienced at present is damage to the cables caused by herring-fishing activities. Other hazards which might be encountered are ship anchors, vibration and chafing on the sea bottom.

The cable will be owned jointly, one-half being manufactured in each country. It is estimated that a substantial saving will accrue to both countries through the operation of this interconnector. Work is expected to begin this year and to be completed by 1960.

CONCLUSION

A paper purporting to range over the whole vast field of energy and power supply in more than brief outline would be intolerably long and diffuse. Even so, the outline I have tried to sketch has been drawn mainly against the background of electrical power development in this country. But if any excuse be required for concentrating on this one form of energy it may be supplied by the fact that in the last thirty-five years consumption of electricity has multiplied by no less than sixteen times. The con current growth of the electricity supply industry and of our national productivity evidences the major role that electricity now plays in our economy.

Electricity, perhaps, illustrates better than any other form of energy the general effect of the use of natural energy which is to enable man to do many things that would otherwise be impossible or, alternatively, to enable him to carry out work much more quickly, and in the role of overseer rather than participant. The result is a shorter working day with less expenditure of physical effort.

But the call on mental effort has been correspondingly stepped up. To design and construct a successful machine requires a knowledge of nature's laws and of the strength and compatibility of materials, which can be acquired only by patient study and experience. Furthermore, the chain of events between cause and effect has been lengthened. Coal from subterranean depths of 3,000 ft. or more, oil from Venezuela or Kuwait, water from the highlands of any continent, uranium from Canada or Africa may be used to cook food, heat the bath water or reproduce the news or perhaps a church service by radio or T.V., in any home, however remote, however obscure. This chain of causation is composed of many links, each of which must take the strain. Perhaps the greatest single difference between primitive and modern mechanised civilisations is the length of the chain of mutual dependence that now exists and the amount of co-operation required to make things tick.

This has opened a new chapter in the story of human relations not only internationally but in industrial organisations. We are members one of another and if the body politic is to remain healthy the organs must act co-operatively.

Recognition of the absolute need for mutual understanding and goodwill, for team work, and fair shares, is the most important ingredient of a mechanised civilisation and we shall neglect it at our peril.

Provided we can establish these relationships the use of natural energy through mechanisation can produce the conditions in which a healthy, happy people are no longer overburdened with their daily toil but can achieve a satisfactory standard of comfort with enough time left over to pursue the things that beckon to mind and spirit beyond the compass of our physical needs.

There is a tendency to-day for some humanists to take a doleful view of science and technology. According to these people we are in process of producing a robot community under push-button control and this process can place unlimited power in the hands of irresponsible leaders with the inevitable result that sooner or later it will be released with destructive violence to annihilate mankind and end it all.

Scientists rarely take time off to reply to this criticism and there is a tendency for the argument to go by default. Furthermore, the defects of human nature are so numerous and the frailty of human wisdom so apparent that there may well be an arguable case for limiting the amount of power at the disposal of any group—if that were practicable. But from the nature of the circumstances in which power is harnessed and knowledge acquired it just is not practicable to slow down scientific discovery or to suppress its application.

The problem must be tackled at its source where humanists and scientists should combine in tireless and unceasing effort to show that science and technology are but means to an end and that that end should be a nobler, simpler, less oppressive life with more time for all the people to enjoy in leisure and reflection.

In this the humanists should take the lead and in so far as they are successful they will have endowed mankind with a critical appreciation of the human situation. This done, men in appointing leaders can make their choice.

There is no more that can be done. Certainly there is no justification for ceasing to harness nature's energy on the offchance that it will be abused. It is up to man himself to see that it is properly used.

GREEN FODDER CONSERVATION*

By C. Culpin

One of the cheapest methods of producing livestock products is to grow grass or other green crops and allow the animals to graze them. Unfortunately, during the winter months, this can only be done to a limited extent, and it is necessary to find other feeding-stuffs to cover this period. It is no longer practicable for British farmers to use large quantities of imported concentrated feeding-stuffs, since these are now quite expensive compared with grass, and their extensive use is ruled out by economic factors, whether the problem is considered on a national basis or from the viewpoint of what is best for the individual farm. Broadly speaking, there are two methods of tackling the problem, (1) to increase the length of the grazing season, and (2) to grow feed grains and green fodder crops which can be effectively conserved for winter feeding. In recent years improvement in the conservation of green fodder crops has become one of the main preoccupations of individual farmers and also of the Ministry of Agriculture. In agriculture, as in other industries, sound progress to-day depends at least as much on increasing the output per man-hour as on other scientific advances, and the contribution being made by what we call " mechanisation " is becoming of ever-increasing importance. This paper describes briefly some of the more important recent developments, and indicates directions in which further progress may be expected.

* Paper read before Section G of the British Association at Dublin on Tuesday, September 10, 1957.

CONSERVATION PROCESSES

It is convenient to divide methods of green fodder conservation into the following main categories:—

(1) Haymaking on the ground.
(2) Haymaking on tripods or other structures.
(3) Hay drying indoors, using little or no heat.
(4) Grass drying.
(5) Making silage.

The first four are all drying processes, and broadly speaking, the losses in nutrients suffered by the crop on average decrease progressively from (1) to (4), while the cost of conservation tends to increase. Thus, when hay is made on the ground with a pick-up baler at a cost which may be in the region of £2 5*s*. per ton, the loss of nutrients may amount to 2/5ths of the starch equivalent and 1/3rd of the protein equivalent originally present in the crop; whereas grass drying, which may cost in the region of £15 per

ton of dried product, can result in total nutrient losses of less than 5 per cent. Generally speaking, the more expensive conservation methods can only be economically employed for crops of high initial quality.

Silage making has been practised on a limited scale for a very long time, but it was not until quite recent years that the advent of fully mechanised methods made the process suitable for widespread adoption. There is still much to be learned about the chemistry of this method of conservation, but the rapid progress in mechanisation recently achieved has helped not only to bring about the necessary saving in labour but also to improve the average quality and uniformity of the product to a marked extent. It must be emphasised that conservation without excessive loss of nutrients is the primary object in all of the conservation processes. A low labour requirement and the elimination of drudgery are important, but never more important than the fodder quality aspect.

CUTTING GREEN CROPS

A cutter bar consisting of triangular knife sections which reciprocate over stationary "fingers" has been a feature of grass mowing machines for over a century. Some essential features of the cutter bar have been standardised (British Standard No. 1562:1949) and the cutter bar itself is now usually one of the tools specially designed for operation by tractor, being power-take-off driven, and often mounted on the tractor where the driver can easily see it. The most modern mowers are dynamically balanced and so capable of operating at much higher speeds than those in general use. However, the small size of the average farm makes cheapness of the equipment a prime consideration for manufacturers, and it may be a long time before dynamically balanced mowers are in general use for fodder conservation.

In the meantime, machines now being used and further developed for cutting and loading crops in one operation tend to do the cutting by means of high-speed rotary knives which do not employ a shear-plate. The rotary cutters available are not at present ideal machines for haymaking, but the possibility that the rather troublesome conventional type of cutter-bar has had its day cannot be ruled out. Quite apart from the maintenance troubles associated with conventional cutter-bars, the type of work that they do is not really ideal for haymaking. The idea that the grass which is to be made into hay should first be laid in flat, tightly-packed swaths is one that dies hard; but research has shown that in good drying conditions (in which alone the hay should be cut) a very early breaking up of the swath by tedding or similar treatment is desirable. Some farmers have already used for haymaking, machines which are designed to cut, lacerate and load crops for silage; and it seems likely that it might be worthwhile to develop a rotary cutter designed from the start to deal with hay as well as silage.

MACHINES FOR MAKING HAY IN SWATH OR WINDROW

The development of machines for assisting the drying of hay in the swath or windrow reveals some interesting trends. For a long time hay tedders were frowned on because of their tendency to knock the tender and nutritious leaves off fodder crops, thus reducing the feeding value both qualitatively and quantitatively. It has now been realised that the time to use tedders is in the early stages of drying. Then the mechanical damage to the leaves is small, and tedding helps to minimise the tendency of the leaves to dry much more rapidly than the stems. Modern tedders are mostly power-take-off driven, and there is at present a continuance of an interesting and very old tussle between single-purpose machines and those designed to do one or more other jobs such as swath turning and side-raking.

For collection of the hay, the pick-up loader for delivering long hay on to wagons has been almost entirely superseded, first by tractor-mounted hay sweeps, and latterly by various types of automatic pick-up baler. The pick-up baler is popular not only because it makes the hay easy to collect and store, but also because the baled product facilitates subsequent feeding. Unfortunately, the quality of the product often leaves much to be desired. If the hay is baled too early, or if there are particularly damp patches of hay among the drier material, heating and/or moulding may occur and the result may be a feed of very inferior value. If, on the other hand, the crop is left out too long before baling, serious losses from shattering of leaves, leaching by rain and bleaching in the sun may occur, and the crop may even be completely spoiled. For these reasons, many farmers are willing to change over to other methods of haymaking which will result in improved quality of the product, even though these methods require considerably more labour.

HAYMAKING ON TRIPODS OR OTHER STRUCTURES

One fairly certain way of making some hay of reasonable quality is to load it by hand at the right stage on to tripods, tetrapods, hut racks, or wire fences. The loading of such devices can be assisted in a variety of ways, two of the more attractive being: (1) the use of a buckrake on a hydraulic tractor loader for loading a collapsible type of hut rack, and (2) a new pick-up loader for loading tripods in a travelling container. The first appears to be a suitable method for small and medium-sized farms, while the latter is proving quite successful on large farms, where the cost of the rather complex machine can be justified. There appears to be considerable scope for the development of such haymaking methods.

TABLE I.—*Comparisons of Haymaking Methods*

	Cold air plants	Medium air speed plants with heater	High/low air speed with heater
Fan output in relation to floor area (cub. ft. per min. per sq. ft.)	25	25	60 maximum cold 20 warm blow
Maximum loading depth, ft.	16	16 8 when heat used	8
Air temperature rise and duration	Nil	10-20 deg. F. in last stages of drying	10-25 deg. F. in last stages of drying
Field drying time, days	3	2–3	1–2
Moisture content at loading, per cent.	35–50	35–55	45–60
Weight of typical batch (dried), tons	5–10	5 (when heat used)–10	1–4
Drying time in barn, days	15	7–10	3–6
Capital cost of a single unit (in existing barn)	£200 per bay of 350 sq. ft.	£250 per bay of 350 sq. ft.	£500 per bay of 350 sq. ft.
Running cost (fuel and power only) per ton (all-electric)	10s. to £1	10s. to £2 10s.	£2 to £5

BARN HAY DRYING

The "Mow" drying of hay was first practised on a commercial scale in the United States. The process consists essentially of removing moisture as rapidly as possible in the field, and loading the hay into the barn in a partly-dried condition, where the job is completed by forced ventilation either with or without the use of supplemental heat. The process, after some early vicissitudes, is gradually becoming established in Britain, where three main types of installation are being used, chief characteristics of which are briefly as indicated in Table I.

The importance of getting rid of as much moisture as possible out in the field is indicated by the figures given in Table II, which show the amount of water that has to be driven off in order to produce dry hay at 20 per cent. moisture content (wet basis) from various initial moisture levels. The advantage of the plants which employ shallow layers and a high air speed is that they can operate effectively (though less economically) even when weather conditions are adverse, whereas the cheaper plants require a reasonably long spell of fine weather before the crop can be taken in.

TABLE II.—*Weight of Water to be Driven Off to Produce Dry Hay*

Moisture content of hay, per cent. (wet basis)	Weight of water to be removed to produce one ton of dry hay, cwt.
70	33
60	20
55	16
50	12
45	9
40	7
35	5
30	3
25	1

Up to the present, development has been based mainly on the use of electrical energy. There is considerable advantage in warming the drying air when atmospheric conditions are adverse (cold and damp). Electrical heating of the air is economic where use of the heat is very carefully controlled, but to facilitate a widespread adoption of the more advanced techniques, portable ventilating units which incorporate a less expensive source of heat than electricity might well be developed. Oil-fired heat-exchanger units are widely used in the United States.

The latest and most attractive development of the barn drying process is that of drying previously baled hay. This permits use of the labour-saving pick-up baler, minimises the difficult task of securing even packing of hay into the barn, and facilitates handling generally. Experience to date suggests that if this new process is applied in a sensible way, due regard being paid to all the many possible pitfalls, this technique can revolutionise haymaking in Britain within the next few years.

GRASS DRYING

No paper on green fodder conservation would be complete without mention of grass drying. This method of conservation is well established, and is able to compete with other methods in its own proper field—that of the production of a high-protein concentrated food. The subject of grass driers and the ancillary field equipment, together with the grinding and cubing equipment, is, however, such a wide one that no attempt can be made in this paper to do more than state the opinion that this technique will continue to have a place in the conservation of herbage of the highest quality.

SILAGE MAKING EQUIPMENT

Silage making is now well established in Britain but there is wide scope for further progress in labour-saving aspects and also in regard to securing a product of uniformly high quality. The simple buckrake mounted on the tractor's hydraulic lift mechanism has been very successful in making this method of conservation suitable for small farms as well as large. Fairly inexpensive machines which cut the crop by means of high-speed rotary knives, bruise or chop it and deliver it direct to trailers are now available. One of the aims is to produce a silage of lower moisture content than the growing crop, and this unfortunately means that a measure of drying of the cut crop in the field is of tendesirable. A machine which can either cut the crop or pick it up from a previously cut swath is an advantage, and now that simple machines capable of doing this are available, a wide extension of their use may be expected. Here again, it would be a considerable advantage if the preliminary cutting could be done with a simple rotary mechanism which would leave the herbage in a state suitable for rapid drying when conditions are favourable.

CONFERENCE ON FLAMES AND INDUSTRY

A one-day symposium on "Flames and Industry" is to be held on October 9 by the British Flame Research Committee, 11 Park-lane, London, W.1, in collaboration with the Institute of Fuel, at the Institution of Civil Engineers, Great George-street, London, S.W.1.

The papers to be presented will deal not only with further results of research on flame radiation but also with the significance, in practice, of these results in various industrial applications. The authors will include Mr. E. Burke, Dr. W. B. Carlson, Dr. J. H. Chesters, Professor H. C. Hottel, Mr. E. H. Hubbard, Mr. S. Kruszewski, Mr. R. Mayorcas, Mr. A. E. Pengelly, Professor O. A. Saunders and Professor M. W. Thring.

The proceedings will be opened at 10 a.m. by the President of the Institute of Fuel, Mr. J. R. Rylands, and the chairman at the morning session, from 10 a.m. until 12.30 p.m., will be Professor O. A. Saunders. In the afternoon Dr. D. T. A. Townend will preside.

Enrolment forms and advance sets of papers may be obtained from the secretary of the Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. Further details, or enrolment forms only, are obtainable from the secretary, British Flame Research Committee.

Book Reviews

PREVENTING BREAKDOWNS

Maintenance Engineering Handbook. By L. C. MORROW. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (20 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (150*s.*)

Preventive maintenance of engineering equipment, plant and facilities is now accepted as a necessity by most progressive industries. A preventive maintenance system is designed to anticipate equipment defects so that corrective action may be taken before failures occur.

A breakdown in any of the many processes or machines in modern factories can prove very expensive and create serious production delays. As automatic machinery replaces manual work, so more emphasis will necessarily be placed on adequate and timely maintenance to reduce breakdowns to a minimum. The cost of maintaining plant and facilities will tend to become a progressively larger proportion of the total manufacturing cost. Thus, economy in undertaking maintenance processes must be studied with care. Fortunately, most maintenance engineers now appreciate that a continuous watch on maintenance costs is as essential as the technical aspects of the work, and that such matters can no longer be left entirely to the firm's accounting department.

The prerequisite of an efficient preventive-maintenance system is the adequate planning and organisation of the system and the work, so that inspections, routine work and repairs can be undertaken with the least disruption in production and the minimum of unserviceable equipment time. A well-planned system enables maintenance costs to be estimated well in advance, and indicates items requiring either more or less frequent attention. Items which cost more to maintain owing to their inferior design are highlighted and action can be taken to obtain improvements. Manpower can also be employed to the best advantage. As a result, lost time is minimised and this is an important consideration when skilled tradesmen are difficult to obtain.

This American book is a comprehensive work of reference for plant maintenance engineers. Persons engaged in the other specialised branches of maintenance engineering, as well as industrial management staffs, will also find much of value. The information included in the handbook has been written by practising American specialists in each field and can be regarded, therefore, as authoritative and up to date. Chapters are included which cover every aspect of plant equipment, facilities and industrial buildings. Adequate guidance is given to plant engineers and plant management staffs to enable them to introduce improvements in the organisation, efficiency and economy of the establishments they control.

A considerable part of the book is devoted to administration, personnel management, and the planning and scheduling of work. Much emphasis is placed on work measurement and on preventive and planned maintenance. Many examples of suitable forms for recording and planning operations are provided. Two sections are devoted to project control, and cost control and budgeting, respectively, with which subjects, we venture to think, many plant engineers may not be very familiar. Sections are provided covering the upkeep of buildings, and of mechanical, electrical and servicing equipment. These sections include examples of defects requiring rectification, suggested methods of repair, and suitable routine maintenance schedules. The remaining sections supply information regarding stores and stores control, lubrication, instruments, sanitation, welding and corrosion control.

In a comprehensive work of this type it is inevitable that some items have either to be omitted altogether, or covered only briefly. For example, in the present volume some particulars are given respecting sprinkler systems for fire control, but information regarding the maintenance of other fire equipment normally provided in engineering works is not included. Details concerning the maintenance of mechanical-transport equipment have been limited to electrical and internal-combustion-engined industrial trucks. Some useful information on training methods for fork-lift drivers is included.

The establishment and organisation of a "standards" room or section to undertake the responsibility for checking and repairing all works testing equipment, such as torque spanners, micrometers, and mechanical and electrical instrumentation, has not been included. A section of this kind is a most important factor in present-day maintenance techniques and one which is regarded as essential in most engineering works employing precision machinery.

The section of the handbook covering stores and stores control includes examples of general storage methods, but would be improved by the inclusion of suggestions for the correct storage of specific materials, such as timber, rubber, paint, oxygen, and so forth, which require specialised storage to prevent deterioration and to avoid danger. It is unfortunate that some of the standards and recommendations given in the book do not coincide with those commonly used in Britain. Some of the value of the book, to British readers at any rate, is lost on that account. This remark, however, is more in the nature of a comment on the lack of international standards than a criticism of the book. The chapters covering personnel management are rather centred on American trade-union agreements and practices. British procedures tend to differ in many respects.

To summarise, this book would make a very useful addition to any plant maintenance engineer's library of reference books, since it contains valuable information for the maintenance staffs of any engineering organisation. The differences between British and American techniques, standards and practices need to be taken into account, however, when using the handbook.

PROBLEMS IN THE AIR

Elements of Gas Dynamics. By H. W. LIEPMANN and A. ROSHKO. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (88*s.*)

Here is the long-awaited successor to Liepmann and Puckett's *Introduction to Aerodynamics of a Compressible Fluid*. That volume filled a great need when it appeared in 1947, since it was the only comprehensive and authoritative text on the subject which conventionally educated engineering aerodynamicists could buy. The reviewer feels that the whole of this situation has been brought up to date with the present volume. "Sonic bangs" no longer provoke Press correspondence, aeronautical engineers now have a reasonable knowledge of supersonics and again there is a masterly text-book from "Caltech's" Professor Liepmann to put the fundamentals on a sound enough basis to enable the reader to look into the future. The exciting research topics of yesterday become "classical" to-day, and conventional supersonics cannot cope with the difficult problems of aerodynamic heating, hypersonics, flight through air of extremely low density, etc. This accounts for the changed title of the work. It is now necessary to build on a far more thorough grounding of thermodynamics than used to be the case, and this grounding is provided. Admittedly the reader will not be able to estimate the amount of dissociation and ionisation produced by the strong shock waves which travel ahead of a "re-entering" ballistic missile but he will learn how some of the work done by the drag is converted into forms of energy which are not normally spoken of in engineering schools.

However, the authors are research engineers rather than research scientists, and the reader is never left long to wonder why any topic has been included. The chapter headings are: Concepts from Thermodynamics (34), One-Dimensional Gas Dynamics (23), One-Dimensional Wave Motion (22), Waves in Supersonic Flow (36), Flow in Ducts and Wind Tunnels (22), Methods of Measurement (33), The Equations of Frictionless Flow (23), Small Perturbation Theory (14), Bodies of Revolution. Slender Body Theory (31), The Similarity Rules of High Speed Flow (16), Transonic Flow (17), The Method of Characteristics (24), The Effects of Viscosity and Conductivity (44), Concepts from Gas Dynamics (55). The numbers in parentheses give the number of pages devoted to each chapter. The authors have resisted the temptation to impress the reader with their knowledge of up-to-date research papers and the 45 references given are carefully selected. At the end of the book there is a set of 105 exercises. Many of these are too difficult for an individual reader.

Finally it may be said that the publishers do not err in their claim that the book "supplies the physical background for work in modern gas dynamics and high speed aerodynamics."

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INDUSTRIAL PHOTO-ELECTRICS

Photosensitors. By W. SUMMER. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (105*s.*)

This book bears the sub-title: "A Treatise on Photo-electric Devices and Their Application to Industry," thus defining photosensitors, a word coined by the author. Part I of the text describes photocells and associated apparatus, and Part II applications.

In recent years there have been notable advances in photo-electric devices, some stemming from the study of solid-state physics and others from the needs of nuclear research. The photo-transistor, the cadmium sulphide photocell, and the photoconductive television camera tube, fall into the former category, and the photomultiplier into the latter. The first three devices have the virtues commonly associated with semiconductors, being small, robust and efficient. They also have two unfavourable characteristics of most of their class—limited temperature range and rather slow response to a changing input.

Photomultipliers, on the other hand, have an almost unlimited speed of response, but tend towards greater bulk and fragility, and are adversely affected by high temperatures. Their sensitivity is truly remarkable, enabling them to detect the light from individual nuclear events and even individual photons. Such tubes are now produced in thousands.

The use of industrial television is currently increasing; probably to be attributed partly to the advent of the small inexpensive photoconductive camera tube, and partly to the diminishing mistrust of electronics by industry. The latter trend also enables photoelectric devices to be used in commercial processes, either as controlling or monitoring elements.

The book as a whole contains a vast amount of information from a very wide field. It is to be regretted that not all the information is as relevant, up to date, or accurate as would be expected from such an expensive volume. For example, a "nomogram of chimney losses and fan loads expressed in lb. of fuel fired," however

useful, is hardly appropriate; and the calculation of quantum yields of photocells to seven significant figures is not really justified. The applications list by the author, containing 375 items, has many repetitions—over half-a-dozen burglar alarms, for example.

The number of examples of the use of photocells could well be reduced drastically, and a detailed description of a few installations given, together with some design philosophy, such as fail-to-safe features. The influence of random noise at low levels could also be included to advantage. The Aniseikon is referred to frequently in the book, but the device is not explained satisfactorily.

The bibliography contains 2,648 references, less than 20 being as recent as 1952, and the remainder earlier. Used in conjunction with the text, it may give those with knowledge of the art useful leads. The wealth of information in the book may prove attractive but some degree of caution should be exercised as rapid developments are occurring in this field.

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NEW BOOKS

Higher Control in Management. By T. G. Rose. Sixth edition. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (30*s.*)

The fact that a sixth edition of this text-book has been called for is surely a sufficient indication that it meets the needs of a wide section of the managerial world. Since its first publication in 1934 (a second edition was required in the following year), the book has gained many friends. It is clearly written and is illustrated by a number of tables, forms and diagrams, and some of the charts it contains are in colour. Its practical outlook is doubtless due to the author's engineering qualifications and experience. He is a Member of the Institutions of Mechanical Engineers and of Production Engineers, and was formerly works manager of Leyland Motors Limited. The present edition is an amendment of that of 1950, but, even so, a few references have been retained which give the book a somewhat elderly look, such, for example, as the commencement to the chapter on The Technical Position, which states: "In the year 1926, when Mr. A. H. Pollen became chairman. . . ." Much has happened during the past 30 years.

Technical Reports of the Electrical Research Association, *Thorncroft Manor, Dorking-road, Leatherhead, Surrey*:—

"Polarizability of a Dilute Solid Solution of Dipolar Molecules at Low Temperature," by J. A. Sussmann, L/T347 (9*s.*); "Models of Materials with Loss per Cycle nearly Independent of Frequency," by H. Pelzer, L/T359 (10*s.* 6*d.*); "Radio Interference from High Voltage Distribution Systems," by S. F. Pearce, M/T122 (10*s.* 6*d.*); "Electromagnetic Forces in Transformers with Multi-Layer Windings," by M. Waters, Q/T143 (12*s.* 6*d.*); "The Effect of Core Properties on Axial Electromagnetic Forces in Transformers with Concentric Windings," by M. Waters, Q/T144 (6*s.*); "A Stable Decade Amplifier for the Frequency Range 10 c/s to 1 Mc/s," by D. C. G. Smith, V/T120 (10*s.* 6*d.*).

Imperial College Inaugural Lectures, 1955-1956. *Imperial College of Science and Technology, London, S.W.7.* (No price given.)

At the request of the Government, a major expansion of Imperial College was undertaken in 1953, aimed not only at effecting an increase in the number of students but also in widening the range of its work and specialised studies. Many new Chairs in the University of London were established and filled at the College. Early in 1955, all new Professors, including those succeeding to the older Chairs, were invited to deliver an inaugural lecture, and the lectures so delivered are reproduced in this volume. The lectures are: "The Future of Imperial College," by R. P. Linstead; "Thermodynamics in the World of To-day," by A. R. Ubbelohde; "Photo-Electronic Aids to Scientific Observation," by J. D. McGee; "Some Tasks and Perspectives in Physical Chemistry," by R. M. Barrer; "Technometrics and the Mathematical Needs of Modern Technology," by G. A. Barnard; "Soil Mechanics and Its Place in the University," by A. W. Skempton; "The Next Ten Years of Electrical Engineering," by Arnold Tustin; "Applied Geophysics in Retrospect and Prospect," by J. McG. Bruckshaw; "Reflections on the Education of Engineers in a University," by D. G. Christopherson; "The Control of Processes," by Arthur Porter; "The Aircraft Under Stress and Strain," by J. H. Argyris; and "Inorganic Chemistry: Some Views on the Renaissance," by Geoffrey Wilkinson.

On the Shelf

By Frank H. Smith

The Stationery Office has recently published (at 22*s.* 6*d.*) *Scientific Research in British Universities*, compiled by the Department of Scientific and Industrial Research. This is a most useful volume which lists the universities and university colleges of the United Kingdom (British is rather sweeping) and the researches that are being carried out in them. The senior staff responsible are also given and their names are indexed at the end of the book, as are the subjects covered. Thus it is possible to find out in a matter of seconds what Joe Bloggs is investigating and where he is doing it. Similarly, one can find out who is researching into eclampsia; ganglionic synopses; leg, length inequality; or even the 18 different bodies investigating fatigue of materials. Somewhere I feel there must be someone doing spelling reform because I see from the introduction (unfortunately anonymous): "their (*sic*) is no mention of temporary staff, or staff too junior to supervise research students, or students themselves."

Yearbooks and handbooks should be collected willy-nilly by any librarian in charge of a reference library. It does not matter two hoots whether they have a direct bearing on his subject—he never knows when he may need them. Take, for instance, the *British-Swedish Chamber of Commerce in Sweden Year Book* 1956-57. The title is fairly self-explanatory but it is still quite surprising what a useful collection of addresses is to be found inside, besides various economic and trade statistics and tables. I imagine that there is a high percentage of bi-lingualism in Sweden yet in the trade section of the *Year Book* there is not a single English bookseller. I am glad to see that *this* journal is one of the four English firms listed under "Printers and Publishers." Further information can be obtained from the Secretary of the London Committee, c/o Sir Harold Wernher, 15, Grosvenor-square, W.1.

An interesting map has been produced by the Petroleum Information Bureau, 29 New Bond-street, London, W.1, at 2*s.* This shows the world's oil producing and refining countries and the production figures for 1956. It might be a good idea were this drawn to the attention of education authorities because it is just the sort of thing that children look at and learn from when it is put up on a classroom wall.

On May 31 I mentioned a Science Library production, *Books on Engineering*. A mimeographed supplement to this can now be obtained (Bibliographical Series 745) which will bring the original up to September, 1956. There is no charge for the supplement and application should be made to the Science Museum Library.

Microfilm collectors should apply to University Microfilms, 313 N. First-street, Ann Arbor, Michigan, U.S.A., for their 1957 catalogue. This lists a considerable number of standard journals (there is at least one notable omission) which are available in microfilm form, together with the subscription rates.

The Ministry of Education, in a ten-line announcement, gives the membership of the Committee on Public Libraries in England and Wales. In the White Paper on local government functions which was published in May it was said that the "exercise of the function concerned with libraries would be considered in the context of the library service as a whole" (whatever that means) and this committee is to consider that question. It will "consider the structure of the public-library service . . . to advise what changes, if any, should be made in the administrative arrangements, regard being had to the relation of public libraries to other libraries." It is "other libraries" which intrigues me and to the definition of which I shall look forward. Of 15 members of the Committee, none seems to be connected with the type of library I have in mind and I suppose the President of Aslib will be their spokesman. In fact, the proportion of librarians of any kind is remarkably small.

Handbook of British Refrigeration Material and Home and Overseas Buyers' Guide, 1957. "*Modern Refrigeration*," *Refrigeration House, Victoria-road, Woking, Surrey.* (25*s.*)

This handbook includes an alphabetical directory of the refrigeration industry; a classified buyers' guide and list of trade names; an illustrated catalogue of products in four sections—machinery, power and plant equipment, insulation and refrigerator construction, instruments; and data on the British Refrigeration Association, the Department of Scientific and Industrial Research, the Institute of Refrigeration and the National Federation of Cold Storage and Ice Trades, directories of quick-freezing processes, frozen food distributors, cold stores and ice factories, and a technical section including refrigeration tables and technical data.

Surveying: Elementary and Advanced. By William Horace Rayner and Milton O. Schmidt. *D. Van Nostrand Company, Incorporated, 120 Alexander-street, Princeton, New Jersey, U.S.A.* (8.50 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (63*s.*)

Intended to serve the student while engaged in his studies and, later, after qualifying, when engaged in professional practice, this work combines the authors' *Elementary Surveying*, third edition, and the senior author's *Advanced Surveying*, second edition revised, within the covers of a single text-book. At the same time, as the authors point out in their preface, the many details of technique are properly left to be acquired outside the classroom and in subsequent practice; but their explanation of fundamentals is well done. The advanced section, which comprises about 550 of the book's 900-odd pages, "has been thoroughly revised and expanded," and a new chapter, on special surveys, has been added. The book is primarily intended, of course, for American readers, so that, apart from fundamentals the examples dealt with are taken, naturally, from United States sources, and the apparatus shown among the book's 567 illustrations is American. Useful lists of references terminate the later chapters. These, too, are to American sources, but there is a reference, in an interesting chapter on the History of Surveying, to Wilfrid (not Wilfred) Airy's article "The History of Land Surveying in England," which appeared in Engineering, vol. 87, page 341 (1909).

A Scientific Sampler. By Raymond Stevens, Howard F. Hamacher and Alan A. Smith. *D. Van Nostrand Company, Incorporated, 120 Alexander-street, Princeton, New Jersey, U.S.A.* (6 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (45*s.*)

Rather more than 200 short "reports, predictions and reflections" which have appeared during the past quarter of a century in the *Industrial Bulletin* of the United States research organisation, Arthur D. Little, Incorporated, are contained in this volume. They are classified into 15 chapters—ranging from The Inner Man to Inside the Atom—with each chapter divided into groups of half-a-dozen or so items. All the items are essentially topical and each one is of real interest, written in an easy-to-read, informative style. Individually, they comprise such subjects as On Eating Molasses, Metals in Foods, From the Royal Archives (Sir Humphry Davy and the Royal Society), Diesel Round the Bend, Space Travel, and The Learned Astronomer. That they are seasoned with humour is apparent from the titles of some of the reports, among which may be mentioned Believing is Seeing, Hue and Why, Code in the Head, Modern Middens (in the Atomic Power group) and Hot Ice. There is a chapter entitled Engineers at Work, which opens, rather excitingly, with a note "On Making Feather Dusters." There are reflections on The Cult of Caviare, Oyster Farms and The Bee Sting. Altogether, this is a book to enjoy and to linger over—and to keep handy for future reference, since there is a brief but competent index.

Production

AUTOMATICALLY MEASURING PITCH ERRORS*

Fir-Tree Root Serrations in Gas-Turbine Discs

By L. W. Nickols, B.SC.(ENG.), M.I.MECH.E., M.I.PROD.E.

About two years ago a comparator[1] for measuring the pitch errors of the fir-tree root serrations on gas-turbine blades was developed at the National Physical Laboratory and is now in use in industry. The comparator to be described is complementary to the above instrument and measures the pitch errors of the corresponding fir-tree root serrations in which the blades are mounted on the periphery of the disc. Both comparators have been designed to measure the pitch errors of the pressure flanks of the serrations, i.e., the flanks that take the load under operating conditions. The tolerances on the pitch of the pressure flanks amount to only a few ten-thousandths of an inch and a high accuracy of measurement, $\pm$ 0·0001 in. ($\pm$ 2·5μ) or better, is required. The new comparator, for which a patent application has been made, measures the pitch errors speedily and to the desired accuracy by comparison with a composite slip-gauge standard, the errors found being recorded on a chart.

An indexing mechanism brings each fir-tree root in turn into the measuring position. The pitch errors are then measured by means of a rotating turret fitted with flexibly mounted styluses which engage each serration in turn. The alternate operations of indexing and measuring are carried out automatically.

The disc is mounted with its axis horizontal and is rotated to a position in which the pressure flanks of the serrations on the side of the fir-tree root to be measured are vertical, as shown diagrammatically in Fig. 1. This position is reached when both flanks of the serration nearest the periphery of the disc are brought into contact with a datum stylus which is at the appropriate height above the centre of the disc. The datum stylus is connected rigidly to the body of a horizontal measuring head which is mounted on a spring-strip suspension so that it can move freely in a horizontal direction normal to the pressure flanks. In the measuring position, therefore, the datum stylus is seated in the datum serration and this in turn locates the measuring head in relation to the datum pressure flank.

Each pitch measurement is made by means of a separate calliper, one arm of which incorporates a stylus that contacts the pressure flank being measured while the other arm operates the anvil of the measuring head. The reading obtained on the measuring head is a measure of the distance of the pressure flank from the datum pressure flank.

The callipers are mounted radially around the periphery of a turret, shown in Fig. 2, which rotates about a horizontal axis parallel to that of the measuring head. Each calliper is mounted on a spring-strip suspension so that it is free to move in a horizontal direction with respect to the turret. As the turret is rotated, each measuring stylus in turn engages with the pressure flank it is intended to measure and determines the pitch error midway along the length of each serration.

Adjustments are provided to enable the comparator to be set correctly with the aid of a setting fixture and the errors of pitch are recorded directly on a meter or chart. The turret is rotated by an electric motor and the speed of rotation is reduced automatically at the measuring positions to permit the measuring styluses to engage the serrations without shock and to allow each stylus to move slowly along the serration during measurement. In one revolution of the turret the errors of pitch of all the pressure flanks on one side of a fir-tree root are measured. The datum stylus is then withdrawn from its serration and the turbine disc is indexed around automatically until the next fir-tree root is brought into the measuring position. In one complete revolution of the turbine disc the pitch errors of all the serrations on one side of the fir-tree roots are measured. The pitch errors of all the serrations on the other side of the fir-tree roots are measured after reversing the turbine disc on its mounting.

The general arrangement of the comparator is shown in Fig. 2. A robust iron casting, with its upper surface finished accurately flat, forms the base of the comparator. The turret is mounted at the upper end of a vertical stanchion which is bolted to one end of the base. An electric motor attached to this stanchion drives the turret by means of a belt which engages a large diameter pulley attached to the base of the turret. The measuring head and its suspension are mounted below the turret on a block which is clamped to a horizontal slide.

The turbine disc is mounted on a horizontal mandrel which is supported at its ends in two ball bearings, each one of which is located in a V-block attached to the upper part of a rigid fabricated workholder. The mandrel has an indexing disc attached to it and the turbine disc is indexed around to the correct measuring position for each fir-tree root by means of an indexing mechanism mounted on the rear end of the workholder and driven by a second electric motor. The turbine disc may be removed from or placed in position on the mandrel after lifting the latter from its supporting vee-blocks but without removing the ball bearings and indexing disc from the mandrel. The complete workholder may be moved along the upper surface of the base to withdraw the turbine disc out of engagement with the measuring head mechanism, so as to allow the latter to be set correctly by means of a special setting fixture without removing the turbine disc from the comparator. As the serrations are inclined with respect to the axis of the turbine disc, the

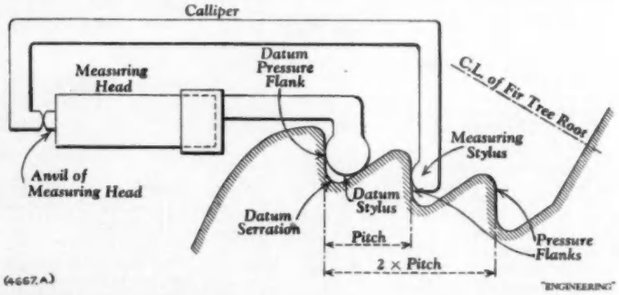

Fig. 1 The datum stylus is seated in the datum serration and locates the measuring head in relation to the datum pressure flank.

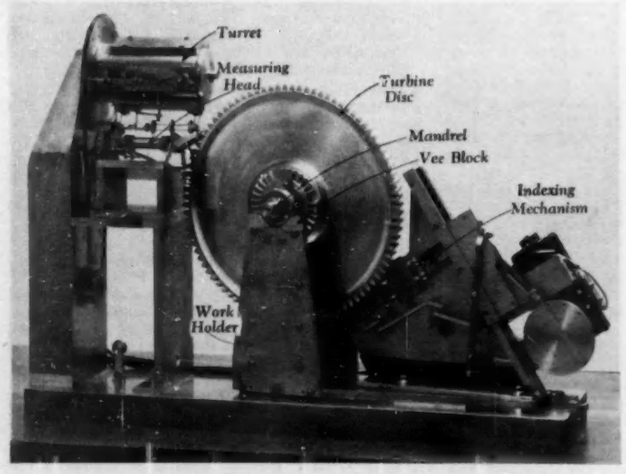

Fig. 2 The turret of the comparator is driven by an electric motor mounted on the upper end of a vertical stanchion bolted to the base.

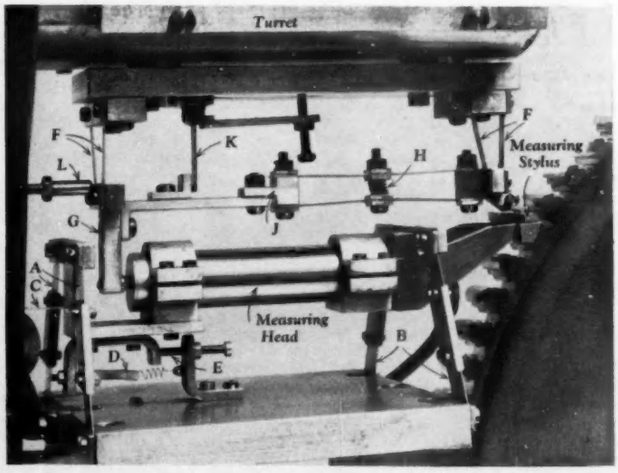

Fig. 3 Each calliper assembly carries a measuring stylus at one end. The other end carries an arm, G, that operates the measuring head.

* Communication from the National Physical Laboratory.

workholder is mounted on the base at an angle such that the pressure flanks being measured are square to the axis of the measuring head.

The various parts of the comparator are described in more detail in the following paragraphs.

MEASURING HEAD ASSEMBLY

The measuring head, shown in Fig. 3, is a Taylor-Hobson "Talymin" electrical gauging head which is mounted in two split clamps attached respectively to similar pairs (A and B, respectively) of reinforced spring-steel strips arranged in the form of two parallel vees. This form of suspension allows the measuring head to move freely in a horizontal direction with excellent lateral rigidity. The datum stylus is clamped to the ends of two arms projecting from the right-hand split clamp.

The datum stylus is withdrawn from the fir-tree root by means of a nylon cord C, running over a system of pulleys, which is connected to a lever operated by the indexing mechanism. When the tension on the nylon cord is relaxed, the tension spring D pulls the measuring head against the end stop E.

TURRET

The turret rotates on ball bearings about a horizontal axis. The body of the turret has five symmetrically disposed flats machined on its periphery, and adjustable calliper assemblies are mounted on these flats, the number of callipers being one less than the number of serrations on one side of the fir-tree root; the remaining flats have balance weights attached.

Each calliper assembly is mounted on two similar pairs F (Fig. 3) of spring-steel strips arranged in the form of two parallel V's. One end of each assembly carries the measuring stylus and the other end carries an arm G which operates the measuring head. The two ends are connected together by means of a strut, the length of which can be adjusted. This strut is constructed of two parallel spring-steel strips connected together rigidly at the ends. Each of the two strips has a central plate attached by means of Araldite. By pulling the two central plates towards each other by means of the central adjusting bolt H, the overall length of the strut is reduced. This type of strut has the advantage that it may be designed to provide a high sensitiveness of adjustment of the overall length in combination with a large range of setting.[2] The particular strut employed has a sensitiveness of adjustment of 0·00001 in. (0·25μ) combined with a range of length adjustment of about 0·005 in. (125μ). In addition to this fine adjustment, a coarse adjustment of the overall length of the calliper assembly is provided by means of a slotted hole at J.

An arrangement for adjusting the measuring force on each stylus is provided in the form of a leaf spring K which bears on a ball attached to the upper side of the calliper assembly. This leaf spring is attached rigidly to a lever which pivots on the body of the turret, and when the set screw at the end of the lever is suitably adjusted an appropriate force is applied to the calliper assembly to bring it into contact with an end-stop L. Each end-stop has a screw adjustment and is set so that when the measuring stylus is disengaged from the serration in the disc the stylus is a few thousandths of an inch to the left of its measuring position. The end-stops are mounted on the large diameter pulley which drives the turret. On the opposite face of this pulley, cams are arranged which operate two microswitches, one which switches an extra resistance into the motor circuit just before each stylus engages its serration, thus slowing down the turret to assist the stylus to engage without shock, and the other microswitch stops the turret after each measuring cycle has been completed, i.e., after each revolution of the turret.

In the measuring position the stylus contacts the pressure flank and clears the opposite flank of the serration. The contact face is approximately spherical in shape to provide a lead-in to the serration as the turret is rotated and to localise contact to the mid-point of the pressure flank. The stylus is normally of hardened steel but may be faced with a wear-resistant material such as tungsten carbide.

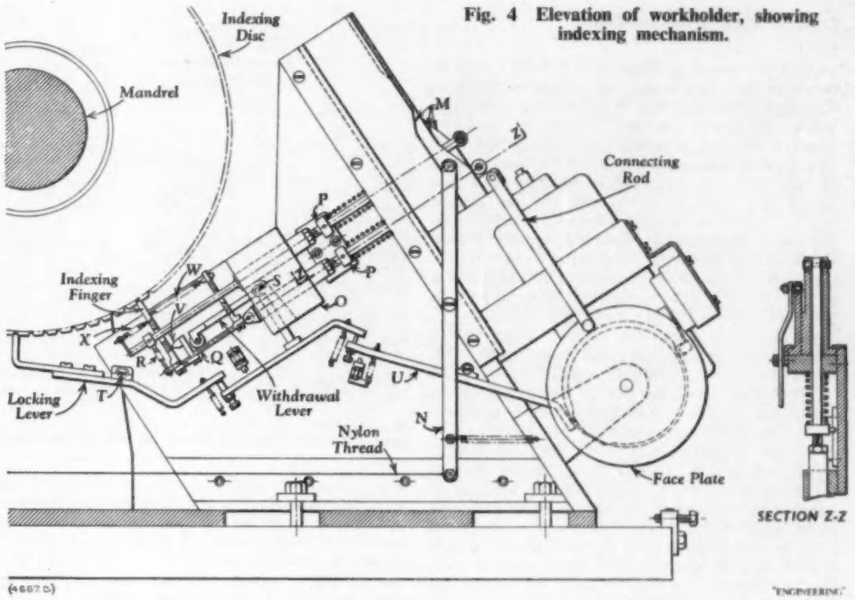

Fig. 4 Elevation of workholder, showing indexing mechanism.

THE WORKHOLDER

The workholder comprises a flat baseplate to which there are attached a vertical plate (carrying the indexing mechanism) and two vertical brackets. These brackets support the vee-blocks (Fig. 2) in which a mandrel rotates. An indexing disc (Fig. 4) is bolted to this mandrel and has equi-spaced vee-grooves equal in number to the number of fir-tree roots on the turbine disc machined around its periphery. The turbine disc is mounted on the mandrel and clamped to the indexing disc. The mandrel has ball-races at each end which seat in the vee-blocks on the vertical brackets. The outside diameter of the ball races is smaller than the internal bore of the turbine disc, thus permitting the disc to be mounted on the mandrel without disturbing the adjacent ball-race. The extreme ends of the mandrel have plain diameters which serve to locate the setting fixture.

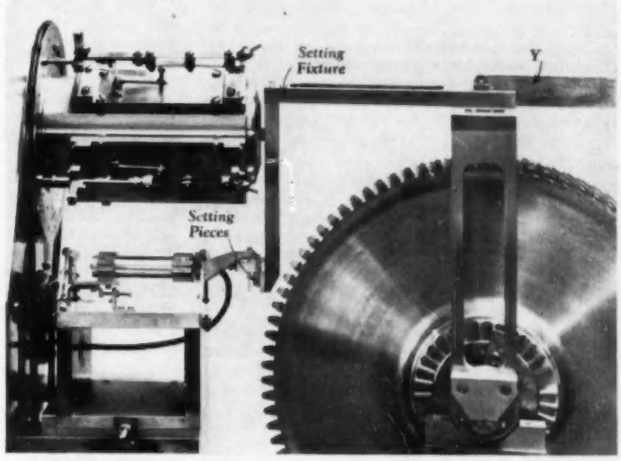

Fig. 5 To set the comparator a setting fixture is used which consists of a built-up frame that bridges the turbine disc.

INDEXING MECHANISM

A small geared motor rotates a faceplate to which a connecting rod is pivoted. The connecting rod gives a reciprocating motion to three formed plate cams M which are bolted together side by side and slide as one unit. All three cams operate spring-loaded followers through the medium of miniature ball-races attached to the ends of the followers. The front cam causes lever N to oscillate about the pivot at its centre; the lower end of this lever is connected by a nylon thread running over a system of pulleys to the measuring head, and the oscillatory movement of the end of the lever allows the measuring head to advance to, or withdraws it from, the fir-tree root being measured. The middle and rear cams give a reciprocating movement to two rods screwed into the ends of plungers which slide in block O. Each rod and plunger assembly is prevented from rotating by a pin protruding from the collar P which engages in a groove in a plate. An L-shaped link Q is hinged to the end of the lower plunger and the indexing finger is hinged to the end of this link. The tension spring R keeps the indexing finger in contact with a vee-groove on the indexing disc. The upper plunger has an extension of reduced diameter which passes freely through slots in the L-shaped link Q and the indexing finger. The withdrawal lever, pivoted at S, and the locking lever, pivoted at T, are operated by means of lever U, which pivots at its central point and is operated by a formed cam on the back of the face-plate. The sequence of operations of the indexing mechanism is as follows.

SEQUENCE OF OPERATIONS

In the position of the indexing mechanism shown in Fig. 4 the measuring head is withdrawn from the datum serration and the datum stylus is clear of the turbine disc. On rotating the faceplate in an anticlockwise direction the locking lever is withdrawn from the V-groove on the indexing disc and then the plungers in block O move to the left simultaneously at the same speed; the hinged indexing finger is retained against stop V by the tension spring W

Continuing **Production**

so that the indexing finger and link Q therefore move as one and rotate the indexing disc and the attached turbine disc in a clockwise direction. When the lower plunger reaches its extreme forward position it comes to rest together with the upper plunger, and the turbine disc is then at rest with the serrations to be measured just below the line of movement of the datum stylus. The lever N now releases the tension on the nylon thread, and allows the tension spring D (Fig. 3) to move the measuring head towards the fir-tree root until it contacts the adjustable stop E (Fig. 3). In this position the datum stylus is above and to the right of, but well clear of, the datum serration. The upper plunger in the indexing mechanism now advances again and, by means of the tension spring X (Fig. 4), pulls the indexing finger so that it pivots about its hinge and rotates the indexing disc in a clockwise direction, thus rotating the turbine disc until the datum serration engages the datum stylus with a force dependent on the strength of the tension spring X. The stop E (Fig. 3) is adjusted so that when the datum stylus contacts both flanks of the datum serration the measuring head moves slightly away from the stop and is located in the direction of measurement only by the datum serration. This is the measuring position.

A second cam on the back of the faceplate now operates a microswitch which starts the turret revolving. The turret is stopped, after making the pitch measurements, by means of the microswitch on the base of the turret. The upper plunger then retracts and allows the tension spring W to pull the indexing finger back against its stop V, the indexing disc and turbine disc rotating back so as to withdraw the datum serration from the datum stylus. The datum stylus is now withdrawn from the fir-tree root by means of lever N. The lever U now operates the withdrawal lever and so withdraws the indexing finger from its V-groove and simultaneously allows the locking lever to engage its V-groove on the indexing disc and lock the latter in position. The withdrawal lever holds the indexing finger clear of the indexing disc while the two plungers retract simultaneously and at the same speed until the indexing finger is opposite the next V-groove, then the withdrawal lever allows the indexing finger to engage this V-groove. The cycle is now complete and the faceplate has turned through one complete revolution.

When the serrations on the turbine disc are being measured, the workholder (Fig. 2) is in the extreme left-hand position, being located by a straight edge at its back and an end-stop at its left-hand end. To set the comparator, the workholder is first moved back along the straight edge until it contacts an end-stop at the right-hand end of the base. The setting operation is then carried out with the aid of the setting fixture shown in Fig. 5.

The setting fixture consists of a built-up frame which bridges the turbine disc when the latter is mounted in the workholder. The fixture is located by two small ball bearings on both sides of the frame which bear on the plain diameter portions at the ends of the mandrel. On the left-hand face of the fixture are clamped a number of setting pieces each of which has accurately flat and parallel working surfaces and a thickness equal to the basic pitch of the pressure flanks of the serrations in the fir-tree root. The setting pieces have their upper ends relieved, and are staggered by the same amount as the serrations being measured in the disc; in effect, therefore, the right-hand working surfaces of the setting pieces represent the pressure-flanks of a perfect fir-tree root. In the setting position, by virtue of the turning moment about the mandrel exerted by a weight at the end of arm Y, the datum serration on the fixture is held in contact with the datum stylus on the measuring head with the same force as that with which the datum serration on the turbine disc engages the datum stylus. The positions of the setting pieces on the fixture are so adjusted that when the datum stylus contacts the datum serration on the fixture the working surfaces of the setting pieces are truly vertical, square to the axis of the measuring head, and the datum serration is in the same position as that occupied by the corresponding serration on the turbine disc.

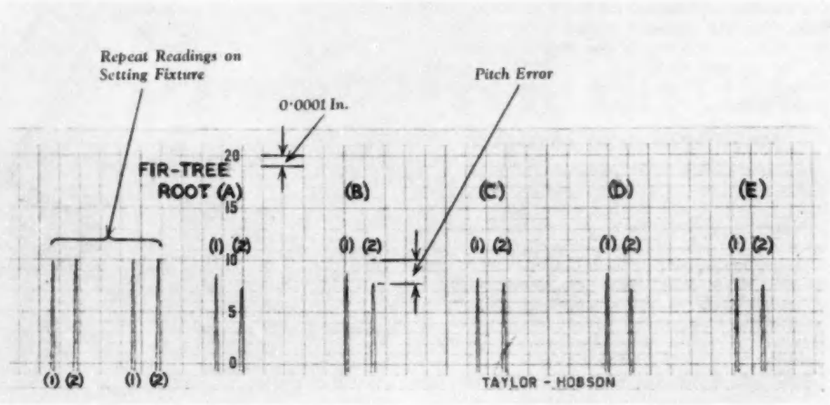

Fig. 6 Chart record of readings on setting fixture and turbine disc.

With the setting fixture in position on the comparator and with the datum stylus of the measuring head engaging the datum serration of the fixture, the turret is rotated until a measuring stylus engages the appropriate working surface of the setting piece. By means of the slotted hole J (Fig. 3) in the strut assembly the length of the latter is adjusted until a reading is obtained on the chart recording unit connected to the measuring head. The fine adjustment H of the adjustable strut is then used to produce a suitable reading on the chart as the measuring stylus sweeps slowly across the surface of the setting piece. The measuring force of the stylus on the setting piece is then adjusted to about 8 oz. (225 grammes) by means of the leaf spring K, and the chart reading re-set if necessary. The end-stop L is then adjusted until it is about 0·004 in. (0·1 mm.) clear of the block assembly in the measuring position.

INTERPRETATION OF CHART RECORD

The above procedure is repeated in turn for the other styluses. The setting fixture is then removed from the workholder and the latter is moved along the straight edge attached to the comparator base until it contacts the left-hand end-stop, and the workholder is then clamped to the base. The turbine disc is now in the measuring position, and when the comparator is operated, the readings obtained on the chart represent the errors of spacing of the pressure flanks with respect to the datum pressure flank.

The recording stylus moves across the chart every time a serration is measured and the end of its travel represents the position of the pressure flank being measured in relation to the datum pressure flank. The traces marked (1) and (2) (Fig. 6) on the extreme left-hand side of the chart are those obtained when using the setting fixture, and represent the basic positions of the pressure flanks spaced respectively one and two pitches away from the datum flank. The other traces on the chart represent the positions of the corresponding pressure flanks on successive fir-tree roots on a turbine disc. The error of pitch of any pressure flank in relation to its datum flank is equivalent to the difference in height of the traces taken respectively on the flank being measured and the corresponding pressure flank of the setting fixture. All the traces marked (1) on the chart are those taken on the pressure flanks spaced one pitch away from the datum flank, and the traces marked (2) are those taken on the pressure flanks spaced two pitches away from the datum flank. The magnification of the Talymin measuring head used is 1,000 times, each small division on the chart in the direction of the pen travel representing 0·0001 in. (2·5μ).

The comparator was constructed in the workshop of the Metrology Division of the Laboratory, and the author desires to acknowledge the assistance rendered by Mr. J. E. Furse in the details of the design and the experimental work.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

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[2] Nickols L. W., "An Adjustable Strut for use in Measuring Instruments." *J. Sci. Instrum.*, vol. 32, p. 149 (1955).

Design

THE RATIONAL METHOD FOR ESTIMATING FLOOD PEAKS*

By James C. I. Dooge, M.E., M.SC., M.I.C.E.I.

Concluded from page 313, *September* 6

In 1851 a number of papers were read to the Institution of Civil Engineers of Ireland by members of the drainage staff. Only two of these will be discussed, the papers by Robert Manning and Thomas Mulvany. Manning's paper gives a very good picture of the approach to hydrology of the Irish drainage engineers. It shows a clear appreciation of many of the important factors involved and serves excellently as a background against which one can judge the paper of Mulvany, who took the final steps required for completing the development of the rational method.

Robert Manning had been recruited to the drainage staff in January, 1846, at the start of the expansion of the works due to the famine.

* Paper read before Section G (Engineering) of the British Association at Dublin on September 5.

TABLE I

Location	Area, acres	Run-off, cub ft. per min. per acre	Date
Crooked River, Cavan	3,500	8·5	January, 1853
Yellow River, Cavan	5,000	16·0	October, 1852
Templemore, Tipperary	5,000	7·4	1852
Aughacushlawn, Cavan	7,000	11·0	October, 1852
Kilbride, Kilkenny ..	8,300	5·0	January, 1851
Glencariff, Antrim ..	9,200	5·4	—
Kilmaganny, Kilkenny	10,560	6·8	1852
Annagh, Galway ..	11,200	13·0	June, 1851
Kilmaganny, Kilkenny	15,000	5·0	January, 1851
Coolaney, Sligo ..	17,600	4·2	January, 1851
Delour, Leix ..	25,216	8·7	January, 1851
Lough Dalla, Mayo ..	32,000	4·0	April, 1850
Templemore, Tipperary	33,000	3·0	January, 1851
Nore, Kilkenny	36,000	2·4	1852
Castlebernard, Offaly ..	42,000	1·9	1852
Killimore, Galway ..	53,000	1·8	February, 1852
Monivea, Galway ..	54,000	1·4	February, 1851
Ardee, Louth	70,280	1·5	November, 1852
Ballyconnell, Cavan ..	90,000	1·4	January, 1853
Dunmore, Galway ..	96,000	1·6	February, 1851
Turloughmore, Galway	196,000	1·5	January, 1853

He served first as a clerk and then as an assistant engineer to Samuel Roberts and afterwards as a district engineer. The paper presented in May, 1951, was the first publication of this renowned engineer, whose name is familiar to all students of hydraulics.

MANNING'S 1851 PAPER

Manning's paper was entitled "Observations on Subjects Connected with Arterial Drainage" and contains an excellent picture of the hydraulic equipment of the Board of Works engineers of the period. Here, however, we are only concerned with his references to hydrology. Following an historical account of hydraulic engineering in other countries and some remarks on the unique nature of the arterial drainage works in Ireland, Manning goes on to say:

"The first subject which claims the attention of the engineer is the maximum quantity of water required to be discharged, and in the absence of all other information, he is obliged to rely on the most accurate information he can procure, as to the extent and duration of previous floods; this, which would at first appear to be a very practical method, is the one most likely to lead to error."

He then cites examples of the effect of drainage works in decreasing the time to peak of floods and hence increasing the value of the peak flow. Having warned against the use of observed floods on an undrained catchment, Manning remarks further on:

"The safest guide for the designs of future drainage will be the results of observations made upon districts already executed. From observations of my own, and from those supplied by the kindness of some friends, I am enabled to give the following general results:—

No. of catchments	Area of catchments, statute acres	Maximum discharge in cub. ft. per min. per acre of catchment	Maximum fall of rain in 24 hours
1	2,300,000	0·44	—
4	750,000 to 1,000,000	0·56 to 0·67	1·75
2	300,000	0·83	1·75
3	150,000 to 180,000	0·83 to 1·00	1·49 to 1·75
4	70,000 to 90,000	0·72 to 1·12	1·20 to 1·83
3	63,000 to 65,000	0·85 to 1·39	0·80 to 1·20
2	30,000 to 40,000	1·25 to 1·81	0·80 to 1·30
1	30,000	2·45	2·00
1	23,000	4·20	2·00

It will be noted that the flows given in Manning's table are less than those plotted in Fig. 1 and listed in Table I. This is due to the fact that Manning was writing before the high floods of 1851 and 1852, which in nearly all cases exceeded the highest values previously observed.

Manning refers to the rudimentary rational method as follows:—

"The method which when carefully applied is the most certain, and when no reference can be made to similar works which have been completed, is the only one which can be adopted, is that which is founded upon the maximum fall of rain, as indicated by the rain gauge, and the extent and circumstances of the catchment basin. Absorption and evaporation, deductions for which are so necessary in calculating the mean discharge of a river, have little if any influence upon the maximum discharge. For it is evident that there may be such a state of the atmosphere that no appreciable amount of evaporation may occur during the continuance of a flood, and no matter what may be the water storing properties of the geological formation of the district, they may have been completely exhausted by previous rains; and, therefore, the maximum discharge will mainly depend upon the quantity of rain, and the extent and comparative elevation of the catchment to the discharging channel. I, therefore, give a table of the maximum quantity of rain in 24 hours, at the places shown (in the table at the head of the page).

Place of observation	Years in which Observations were taken		Maximum quantity of rain in 24 hours		
	Years	No.	Date	Quantity in in.	
Cork	1840–1850	11	17.11.1846	3·60	Royal Institution
Enniskillen	1842–1846	5	12.10.1845	3·02	Lord Enniskillen, Florencecourt
Sligo	1842–1849	8	17.8.1846	1·89	E. J. Cooper, Esq., Markree Observatory
Dublin	1843–1847	5	5.4.1846	1·36	George Yates, Esq.
Castlebellingham ..	1846–1850	5	21.8.1848	1·34	Drainage Commission Office

Although in one or two cases the observed discharge has exceeded the calculated quantity, it has not been found necessary to leave a great margin for errors in calculation."

Manning had not worked in upland catchments and his complacency in regard to the standard method must have been rudely shattered by the observed flows in 1851 and 1852. The above passage is, however, important in so far as it contains a categorical repudiation of evaporation and absorption as the prime factors in determining the run-off factor of the maximum flood. The emphasis on the importance of the size and slope of the catchment is in consonance with the modern form of the rational method, and this position was, apparently, arrived at independently of Thomas Mulvany. However, it is in Mulvany's paper that the work of the Irish drainage engineers reached its full development.

THOMAS MULVANY AND THE RATIONAL METHOD

In February, 1851, Thomas J. Mulvany presented a paper to the Institution of Civil Engineers of Ireland entitled "On the Use of Self Registering Rain and Flood Gauges in making Observations of the relations of Rainfall and of Flood Discharges in a given Catchment." Thomas Mulvany was a younger brother of the Commissioner for Drainage and was, at this time, 29 years of age. He had worked on his brother's staff on the Shannon, and remained on the Shannon after the start of drainage in 1842. He joined the drainage staff during the expansion of the works as a result of the famine, and was appointed district engineer for Counties Longford, Leitrim, Roscommon, Westmeath, Cavan and Fermanagh. His reports and his papers to the Institution reveal him as an all-round engineer of the highest calibre. The paper we are concerned with here deserves to rank as a classic in the development of hydrology. The paper appeared in volume 4 (Part II, page 18) of the *Transactions* of the Institution of Civil Engineers of Ireland. In order to do full justice to Mulvany's originality and discernment, it is necessary to quote extensively his actual words.

After a short introduction, Mulvany states the problem as follows:—

"... the great want of well-established data, and of practical rules deduced therefrom, for the guidance of calculations as to the maximum flood discharge from catchments of various characters, is too well known to require much comment. In fixing the details of a design for any important work of river improvement, many intricate problems present themselves, in the solution of which the Engineer will find that he can receive but little assistance from books, or from the recorded experience of others; and if he relies upon observations to be made with special reference to the case under his consideration, he will find that to lead to correct conclusions such observations should be spread over a very inconveniently long space of time."

He goes on to indicate the existing approach to the solution of the problem.

"For instance, if he has occasion to execute works of a particular class on a portion of a mountain river, and visits the site of the works for the first time in a dry season, he will probably find a very wide and crooked river bed, with a small thread of water running through it; he may ascertain with the assistance of the valuable maps of the Ordnance Survey the extent of district which is unwatered by the river, the general levels of the mountain ridges from which the water descends, and by some personal inspection, with the help of the map, he will make himself acquainted with the general nature of the surface of the country—whether it be of porous nature, so as to retain for some time a considerable portion of the rain water which falls on it, or rocky and precipitous and therefore calculated to discharge the water quickly and with little deduction. But after having ascertained all these facts, and feeling satisfied that each of them must have an important effect on the result as to the maximum flood which he is called on to provide for, he has no faithful guide, that I am aware of, to help him to a conclusion as to the amount of effect on the discharge due to each or all of these conditions; he is, in fact, left to guess at the result after all and, unless he happens to have had some experience of similar cases, his guess will probably be very wide of the truth. If he takes pains to satisfy himself by observations of the results of any flood which there may be an opportunity of observing, he may probably be much misled by assuming that what he sees, and what may indeed be a very large discharge of water, is a maximum discharge, which it may not be, and to produce which a combination of circumstances as to fall of rain and the peculiar character of the catchment may be required, that may not occur more than once perhaps in two or three years, but which it is nevertheless necessary that he should provide for.

We are provided with some data as to the average and maximum fall of rain per diem or per annum in various localities; from which coupled with observations that have been made as to evaporation and absorption, certain conclusions have been arrived at as to the proportion of the rainwater which is usually carried off by the rivers of the country; and in this way rules have been deduced for calculating the discharge which may be expected from a catchment of a given area after a maximum fall of rain. The calculations usually made on this principle show that from 1¼ to 1½ cub. ft. per minute may have to be discharged from each acre."

Mulvany then relates how, in the experience of the drainage engineers, this method was found unsuitable for small catchments, particularly in upland areas.

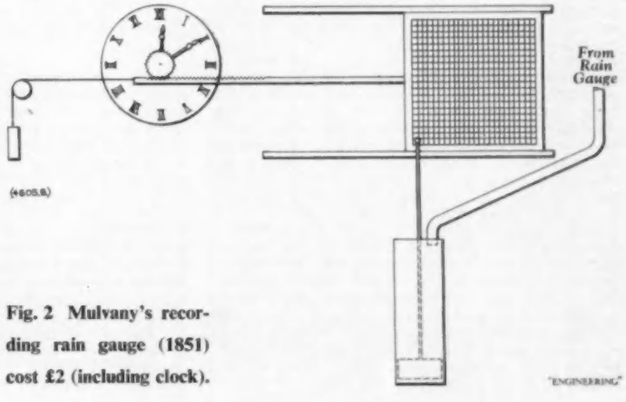


Fig. 2 Mulvany's recording rain gauge (1851) cost £2 (including clock).

Continuing Design

" Now this result, although arrived at in an empirical manner, is found to be tolerably near the truth in catchments of an average character, neither mountainous nor very flat, and within certain limits as to extent. But although the calculations may be depended on for such cases, or possibly for the ultimate result of a large catchment, consisting of a number of sub-divisions which vary much in character and extent, it will by no means apply to each of these sub-divisions. As an instance of the various results which may be found in different portions of the same catchment, I may refer to the Woodford River, in the counties of Leitrim and Cavan. The discharge of water has been carefully measured in various parts of the catchment of this river when different floods had attained to their greatest respective heights, and it has been found that at Ballyconnell, where the river carries off the water of 90,000 acres of country, the greatest discharge in ordinary winter floods was about 60,000 cub. ft. per minute, or two-thirds of a cubic foot for each acre; and in a late very high flood, which may be considered as a maximum, it was found to be as much as 101,000 cub. ft. per minute, or about 1⅛ cub. ft. from each acre; while in the upper portion of this catchment, there is a sub-division of about 5,000 acres, belonging to a mountain river, from which the discharge in floods has been several times found to be from 50,000 to 53,000 cub. ft. per minute, that is, from 10 to 10½ cub. ft. from each acre."

Mulvany states that this wide difference is due partly to " the natural circumstances of the catchments " and partly to " equally important *rates* of fall of rain." He quotes from Beardmore's *Hydraulic Tables* isolated records of heavy falls of rain in short periods in other countries, and remarks :—

" It is stated that 1½ in. of rain in 24 hours may be considered as a maximum fall, on the general surface of this country, but I have not found anywhere a statement of what may be taken to be a maximum fall in one hour, or in any given number of hours.

A widely-spread and long course of observations is required as to the fall of rain in all parts of the country, not merely the daily fall, but the maximum rate of fall for any given portion of time, from a minute or an hour, to a day; and an equally extensive course of observations as to the discharge of water from catchments of various characters, taken in connection with the observations of the rainfall, so as to afford the means of comparing the effect with its cause, and showing, not alone, the greatest or least quantity of water discharged, but the whole quantity in any given space of time, and the rate of discharge at any time that it may be required.

A great mass of authentic data of this sort must be obtained with care, and arranged with system before any successful attempt can be made to generalize the results, or to form anything like a satisfactory set of principles for the guidance of calculations."

Then follows a clear exposition of the idea of the *time of concentration* and of the relation of this concept to the maximum run-off. Mulvany expounds in full the rational method for the determination of run-off from small catchments. Once again it is advisable to quote directly from Mulvany's paper:—

" The first matter of importance to be ascertained in the case of a small or a mountainy catchment, is the time which a flood required to attain its maximum height, during the continuance of a uniform rate of fall of rain. This may be assumed to be time necessary for the rain which falls on the most remote portion of the catchment to travel to the outlet, for it appears to me that the discharge must be greatest when the supply from every portion of the catchment arrives simultaneously at the point of discharge, supposing, as above premised, the rate of supply to continue constant, and this length of time being ascertained, we may assume that the discharge will be the greatest possible under the circumstances of a fall of rain occurring of the maximum uniform rate of fall for that time. Thus, if the catchment be of such a nature as that the rain from all parts of it will reach the outlet in three hours, and if we assume that 1 in. of rain is the greatest quantity known to fall in the locality at a constant rate in three hours, then we may conclude that the greatest possible flood will be produced in that catchment, by such a fall; while twice that quantity of rain, falling in 24 hours, which would be looked upon as a maximum fall, and which would produce a maximum discharge in a different sort of catchment, would, if spread evenly over the 24 hours, produce but a very slight effect, comparatively speaking, on the discharge in this case.

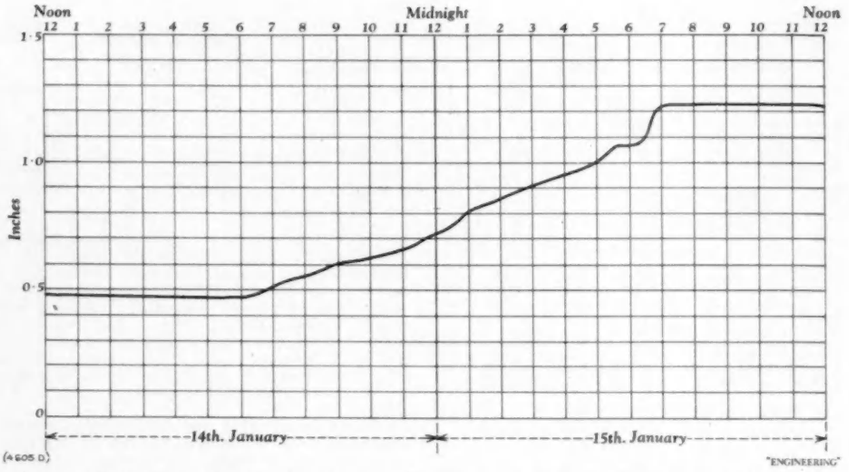


Fig. 3 Chart from Mulvany recorder revealing increase in rate of rainfall over short periods.

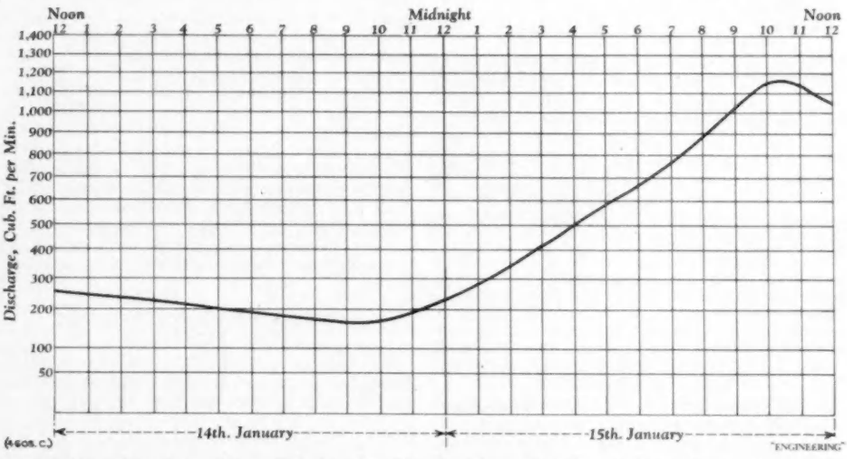


Fig. 4 Run-off resulting from rain in Fig. 3. The chart is graduated to read cub. ft. per min. directly.

This question of time, as regards any catchment, must depend chiefly on the extent, form and rate of inclination of its surface; and, therefore, one great object for investigation is the relation between these causes and their effect; so that, having ascertained the extent, form and average inclination of any catchment, we may be able to determine, in the first place, the duration of constant rain required to produce a maximum discharge, and consequently to fix upon the maximum rate of rainfall applicable to the case. It is evident that, as the space of time is reduced, the rate of the maximum rate of rain is increased. Certain rates of rain may be found to continue for one, two or three hours, that would never be found to last for six or twelve hours; and a certain maximum rate may be observed for twelve hours, that would never continue for a whole day." Having correctly described the manner in which the rainfall rate i in the formula

$$Q = C\,i\,A$$

should be arrived at, Mulvany discusses the problem of fixing the value of C in the following words:—

" The next matter of importance is to ascertain the effect which the various conditions of the earth's surface—as to geological formation, degree of cultivation, etc.—may have on the retention of a portion of the water which falls on it; and thence to determine the proportion of the rainfall which may be calculated upon as to be carried off by the river or drain, under different circumstances.

If observations were made, in the way I have alluded to, on the rainfall and discharge from a great number of catchments, of all varieties of size and character, it appears to me that by selecting a number of cases which may happen to be similar in most of their conditions, but to differ in some one—such as the rate of inclination of their surfaces—and by carefully comparing the results in these cases, correct conclusions may be drawn with regard to the laws of that particular element in the calculation; and so of the others. These investigations may be materially aided by having small and suitable catchments selected specially for the purpose of experiment, as in the case I am about to describe. Of course, the more simple the circumstances of the catchment selected the better for the purpose of the experiment. And if two or more cases could be selected for observation, nearly similar as to form and extent, but varying as to inclination and nature of surface, the comparison of the observations in those cases would be most useful."

The remainder of the paper is devoted to a description of the recording rain gauge and recording flow station set up by Mulvany and Leonard, his area engineer, at Keonbrook on the Ballinamore Canal. The arrangement of the rain gauge is shown in Fig. 2; Mulvany gives the cost as £1, plus £1 or so for the clock. The float was placed in a vessel, the area of which is one-fifth that of the rain gauge, so that 0·5 in. on the chart represented 0·1 in. of rain; a sample chart is shown in Fig. 3. This gauge worked so well that a water-level recorder of similar construction was erected. The discharge of the Ballytrelly Stream (catchment 537 acres) was passed over a 10 ft. wide weir, and the water level recorded on a chart which was specially graduated to read directly in cub. ft. per min. Fig. 4 shows the flow recorded for the same period as the rainfall chart Fig. 3; it is as good a flow record as could be desired.

Mulvany describes an attempt to record the slope by means of a pair of recording gauges in a mountain stream, where the installation of a weir was impracticable. Because of the difficulties with silt in the float chambers, and also of a mistrust of the " universal correctness " of slope formulae, Mulvany abandoned this attempt and decided to use float measurements taken at half-hourly intervals. He remarks that further

tests on the application of recording gauges to mountain streams is very desirable.

It is perhaps well to mention that the discussion on the above paper reveals that the ideas given in the paper were those of Thomas Mulvany himself, and were not a reflection of those of his elder brother, William, who as vice-president of the Institution presided over the meeting. William Mulvany remarked that until he had heard the paper he had been inclined to doubt the accuracy of the measured peak flows from small catchments returned in recent months by his district engineers. Thomas Mulvany has a place in the history of Irish engineering in his own right, and it is a tragedy that his talents, as well as those of his brother, were later lost to his country. Thomas Mulvany left Ireland for the Ruhr in 1857, and was director of the Hibernia and Shamrock mines from then until 1878. In the latter year he and his family went to New Zealand. In 1880, he published a series of articles on the Industrial Development of New Zealand. He died there in 1892, at the age of 71.

SUBSEQUENT HISTORY OF THE RATIONAL METHOD

There has been no essential change in the rational method as propounded by Thomas Mulvany, although some refinements have been made. The method as suggested by him in 1851 contains five essential steps, as follows:—

(1) Measurement of the area, A, of the catchment under consideration;
(2) Estimation of the critical time or time of concentration, t, of the catchment;
(3) Calculation of the maximum rate of rainfall, i, appropriate to the given catchment and the estimated time of concentration;
(4) Estimation of the run-off factor, C, for the given catchment;
(5) Calculation of the maximum rate of run-off, Q, by the formula

$$Q = C\,i\,A.$$

Kuichling (1889), Chamier (1898) and Lloyd-Davies (1906) recommend the same general method, suggesting in addition specific depth-duration relationships (based on rainfall in Boston, New South Wales and Birmingham, respectively) and also particular values for the run-off factor, C. Subsequent writers have tackled the problems of estimating the time of concentration; the effect of a storm covering part of a non-uniform area; the effect of a non-uniform rate of rainfall; and the problem of modifying the method to apply to storms and flows more frequent than the maximum.

In certain cases where the shape of the contributing area is not uniform, it may happen that the maximum flood occurs when the storm covers only part of the catchment area. This rarely occurs in the case of rural areas, but may occur in urban areas. Methods have been developed to enable the designer to determine the critical area producing the maximum flood. The first of these methods was the tangent method developed in England by Reid (1927) and Riley (1931). Their approach was adapted by Escritt to apply to exponential as well as hyperbolic rainfall formulae. A new approach was proposed recently in Australia by Munro (1956).

The area being fixed, the next problem is to determine the time of concentration. This is often done by calculating the velocities in the conveyance channels in various parts of the catchment by some formula such as the Manning formula. As the size of the channel and the flow both vary throughout the catchment, this can be a tedious business. Bransby-Williams in England and Kirpisch in the United States have proposed formulae for the time of concentration of natural catchments.

Rainfall formulae of different types with coefficients to suit local conditions have been used. These were usually some simplification of the following general formula:—

$$i = \frac{a}{(t+b)^n}$$

where

i = rainfall rate
t = duration, and
n, a, b = constants.

Several attempts have been made to allow for the non-uniformity of rainfall during a storm, as this factor influences both the estimation of the critical area in a non-uniform catchment and the calculation of the peak run-off. The first papers on this aspect of the problem appear to have been those of Hawken and Ross (1921) in Australia, and Rousculp (1927) in the United States. Later on there appeared in England papers by Coleman and Johnson (1932), Ormsby (1933) and Hart (1933).

Many tabulations of suitable values for the run-off coefficients C have appeared from time to time. Except in one or two cases, these are based on experience rather than on the analysis of measured data. In urban run-off the coefficients to be used have become almost standard, but their validity has never been demonstrated and further research is being carried out. For natural catchments, the best method so far proposed for estimating C is that of Bernard (U.S.A., 1932), which allows for slope, soil type and manner of cultivation. Though derived for use in the United States, this method has been applied to other areas where alternative figures based on reliable measurements are not available.

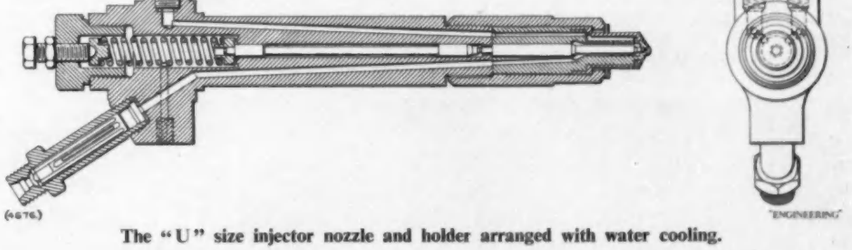
Though the rational method as proposed by Thomas Mulvany was intended to apply only to the maximum run-off, it has since been applied to floods of greater frequency. The fact that the logical basis of the method breaks down when applied to storms occurring more frequently than the maximum has been completely ignored. Horner and Flynt (U.S.A., 1936) found in their analysis on 20 years' records of urban run-off that the value of the coefficient C was more stable if taken as the ratio of a flow of given frequency and the independently derived rainfall intensity of the same frequency and appropriate duration, rather than if C was taken as the run-off coefficient for individual floods. Their suggested definition of C sidesteps the logical difficulty arising from the use of frequent storms. This problem of frequency was tackled analytically by J. E. Nash, when working in the drainage section of the Irish Office of Public Works, and his conclusions were published in the February, 1957, *Transactions* of the American Geophysical Union. It is interesting that the latest paper on the rational method has come from the same engineering office as the original paper by Mulvany over 100 years ago.

There is little doubt that the rational method will be modified in the future to accord with unit hydrograph principles and the infiltration approach. For some time, however, the method will remain a standard tool in the calculation of the storm run-off from small catchments. It is of interest, therefore, to look back over 100 years to the origin of the rational method; to remember the small group of Irish engineers who played an important part in the original development of the method; to trace their uncertain but determined steps and acknowledge their achievement.

WATER-COOLED INJECTOR NOZZLES

In view of the need, in some engines, for water-cooled injector nozzles and nozzle holders, C.A.V. Limited, Acton, London, W.3, have produced the assembly illustrated. This shows a "U" size nozzle and nozzle holder with a length between nozzle-cap nut face and bolting-down flange of 275 mm. Two couplings (1) on the nozzle holder lead to two ducts (2) drilled in the holder. These connect with two similar longitudinal ducts (3) in the nozzle, each of which eventually branches off in a helix that leads into a cooling annulus (4) situated near the nozzle tip. The nozzle is located on the holder in the normal way, by two dowels, to ensure that it is fitted correctly and that the cooling ducts in the nozzle and holder coincide.

Cooling water, piped into the nozzle assembly through one coupling and out through the other, passes through the annulus and cools the nozzle tip. The system is designed for a flow of cooling water of up to 60 gallons per hour and, as a protection against the corrosive action of the water, the cooling ducts in the injector nozzle are nickel-plated.



The "U" size injector nozzle and holder arranged with water cooling.

NEW SWEDISH RIVER MODEL LABORATORY

The Institute of Technology in Stockholm now possesses a new hydraulics laboratory which will provide facilities for large-scale model tests on river and estuary configurations in connection with their possible use as sources of power and for transport. The model hall, together with its immediate ancillaries such as offices, instrument rooms and workshops, occupies about 10,000 sq. ft. Construction was begun in 1955 as an extension to an earlier laboratory built in 1930. The cost of the new laboratory has been about 1½ million kroner (£100,000), of which 275,000 kroner has been given by industry.

Facilities for the laboratory include tanks holding nearly 9,000 cub. ft. of water built under the floor, the water being pumped from there to the models as required by way of a reservoir and a V-notch measuring weir. In addition, a high-pressure pump for testing turbine models and ejector pumps has been installed which supplies over 20 gallons per second with an equivalent head of 650 ft. The model hall can be blacked out in a few seconds by electrically-operated metal curtains so that it is possible to record photographically the movement of illuminated floats carried in the currents on a river model. Work is already in hand on a number of problems including that involved in floating timber down melting rivers. Professor Bo Hellström is director of the laboratory.

Continuing **Design**

ANGLO-AMERICAN AERONAUTICAL CONFERENCE

Influence of Speed on Design

Space flight was one of the topics on which the sixth Anglo-American Aeronautical Conference, held last week at Folkestone, did not touch—and guided weapons were considered only by implication. The expanding boundaries of speed and the difficulties entrained thereby—in engine-intake design, in materials and structures to withstand kinetic heating, in new types of loading, in the effects on the pilot's mental and physical processes, and the necessary instrumentation to take care of these more rigorous conditions—were among the future trends which came up for discussion, as were also the possibilities of nuclear propulsion, and the problems of getting the aircraft expeditiously and safely into the air and down to earth again. A complete list of the papers presented will be found at the end of this article.

Other papers reviewed the development of some of to-day's successful ventures—the electrical throttle controls of the Britannia air-liner, in which magnetic amplifiers were adopted at the time the system originated some ten years ago when they were still rather unconventional in Great Britain; the manner in which Rolls-Royce aero gas-turbines have been developed for repairability (but always with the emphasis on long overhaul life for every part of the engine), and the Rolls-Royce view that, as the aero-engine becomes increasingly complex and compact, it will, like the modern motorcar, become increasingly difficult to repair but will be sturdier in operation and sweeter in performance.

TITANIUM

Also in the category of to-day's fruitful developments is the progress in titanium airframe structures by the Douglas Aircraft Company—an application on which the aircraft industry hold mixed views, although there seems little doubt that in the gas-turbine applications titanium and its alloys have much to offer. In 1948, Douglas adopted commercially pure titanium, then very new, in order to save weight on parts of the X3 supersonic research aircraft—the internal shroud round the tailpipe, the fuselage skin and frames at the extreme aft end, and the tail surfaces. They saved 395 lb. compared with the alternative of stainless steel, and they were successful in producing parts by hand forming, hydro-forming, stretching, rolling, hammering and machining, although they generally found it desirable to heat during forming on these early operations. Later, when Douglas tightened their procurement specifications for the raw material for the DC7 air-liner's firewall and nacelle structures, they found it possible to revert to room-temperature forming operations.

One material defect that occurred again and again was a loss in ductility believed to be due to needle-shaped hydride inclusions. However, elimination of all hydride needles from the microstructure did not cure the defect, and it was found necessary to limit hydrogen inclusions to a maximum of 150 parts per million and to specify a severer bend test and a new tear test on a specially prepared specimen, which when loaded had to tear in a ductile manner. Commercially pure titanium conforming to this latter requirement has eliminated all breakage in the shops. In service in the DC7, only nine parts have been reported to have failed in service, some of these being due to excess hydrogen content (Fig. 1).

Financially, however, Douglas consider that at present-day prices the use of titanium for civil air-liners is not fully justified. They are continuing to use commercially pure titanium, and also alloy sheet and forgings, in the DC8 now being built mainly for the sake of manufacturing experience allied to weight saving.

Fig. 1 Excessive hydrogen content can give rise to service failures in titanium sheet. The crack shown here is in a DC7 nacelle skin.

VTOL, STOL AND BLC

Although the aircraft industry are still asking themselves whether VTOL (vertical take-off and landing) and STOL (short take-off and landing) aircraft are really worth while commercially—whether the penalties in fuel consumption, payload and complexity balance the savings in runways—there seems to be general agreement that, for the high-supersonic piloted military aircraft of the future some such technique will be a " must "; and this subject, above all others at the conference, attracted the widest audience and provoked the most active discussion.

Great Britain, France and the United States are all actively engaged in VTOL and STOL experiments, but the United States have tackled the problem on the widest front. The model experiments carried out by the National Advisory Committee for Aeronautics have been concerned with propeller-powered VTOL and STOL aircraft, both the " tail-sitter " and horizontal-fueslage types, the latter either employing large-chord flaps to deflect the horizontal propeller slipstream through 90 deg. (Fig. 2), or a tilting wing in which the whole wing is rotated about a spanwise axis to the vertical position for take-off and landing; with jet-powered VTOL aircraft, also of the vertical

Fig. 2 NACA deflected-slipstream model for VTOL tests. The deflecting vane arrangement is purely for experimental use.

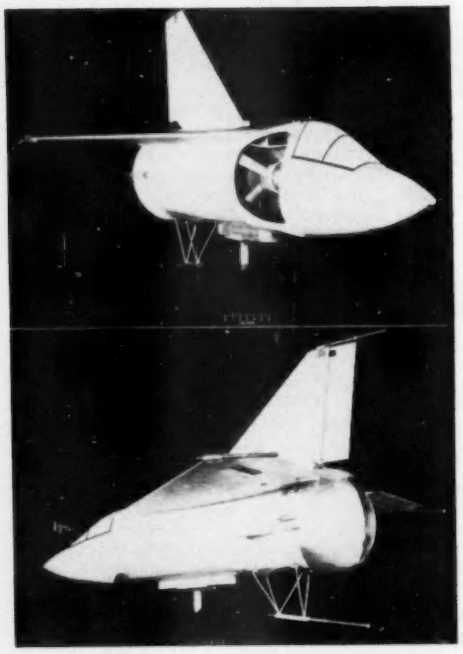


Fig. 3 NACA delta-wing " tail-sitter " jet-propelled VTOL model, in horizontal flying attitude. The jet was produced by a ducted fan.

(Fig. 3) and horizontal-fuselage types, again the latter either employing jet deflection or tilting engines; and with jet-powered STOL aircraft, ejecting the entire jet-engine exhaust as a flattened jet sheet along the wing trailing edge and deflecting it over a flap at the trailing edge, this configuration being known as the jet-augmented flap (as opposed to the jet flap, in which the deflected jet itself forms the " flap ").

Although NACA have generally found it necessary to resort to autostabilisation, in every case they have been able to achieve vertical take-off and landing and transition to horizontal flight without loss of control. Moreover, full-scale trials on the propeller-driven Convair XFY1 and jet-propelled Ryan X13 tail-sitters, and the jet-propelled Bell X14 horizontal VTOL aircraft, have been equally successful and have correlated well with model tests. Nevertheless, NACA consider, much more actual flight experience on full-scale VTOL and STOL craft is necessary before actual operational aircraft can be built.

Closely allied to STOL concepts is boundary layer control (B.L.C.) to increase lift, and here again NACA have made a major contribution to aeronautical knowledge. The NACA studies have been concentrated on preventing flow separation from highly-deflected plain trailing-edge flaps, and on delaying separation from the wing leading edge at high angles of attack—the latter problem being accentuated when boundary layer control is applied to the trailing-edge flaps. NACA have developed two techniques to the practical engineering stage—indeed, aircraft on both sides of the Atlantic are now flying with "blown" flaps—(1) the technique of sucking away through the surface the low-energy air associated with incipient flow breakaway, and (2) the blowing technique of re-energising the low-energy air by a high-velocity jet.

The porous area through which suction is applied to the trailing-edge flap extends rearwards from the minimum pressure point to a point at which the pressure on the highly-deflected flap has increased to the value of the lowest pressure measured on the flap without BLC and without separation. The problem is to maintain a relatively constant inflow velocity over the porous area, where a varying pressure difference exists between the external pressure and the internal duct pressure—i.e., the pressure drop through the porous material must be varied directly as the internal pressure. NACA have accomplished this in several ways. Sintered metals have been used with the density varied from point to point; a very porous surface has been backed by felt or Fibreglass of varying thickness; and metal plate has been perforated with holes of varying diameter and spacing. Wind tunnel results on this type of installation show that, applied to the F.86 aeroplane and assuming a speed of 120 knots, a total pumping power of 10 h.p. would increase the flap lift (at 55 deg. deflection) by 36 per cent., or a lift coefficient increment of 0·2. At higher speeds, the advantage falls off.

In the case of blown flaps, the blowing nozzle is located at, or just forward of, the point of minimum pressure. The jet is supplied from an engine-compressor bleed, and under take-off conditions the nozzle, which is designed for landing speeds and pressures, is throttled to give the optimum pressure ratio. Again applying the NACA data to the F.86, a somewhat higher lift increment can be obtained than in the suction case for a thrust loss of about 5 per cent.

Applying area suction over the full span of the leading edge of a wing absorbs too much power, and a more practical and effective measure to delay flow separation at the leading edge is to apply suction over a leading-edge flap. Still more promising, but still in the early stages of investigation, are blown leading-edge flaps.

NACA model tests have been backed up by full-scale tests on the F.86 aeroplane fitted with area suction on the wing leading edge (Fig. 4), and with area-suction and blown trailing-edge flaps (Fig. 5). Flight-trial and wind-tunnel results have correlated well. No special problems were encountered in operation or maintenance; in particular there was no sign of the porous suction surfaces becoming gummed-up, even in the most adverse weather. The flight trials also aimed at finding pilots' reactions to the use of boundary layer control, and it has emerged that approach speeds can be reduced substantially and that handling is pleasant, and control and stability near the stall is improved, although pilots were worried by a reduction in stall warning when BLC was in use.

(*To be continued*)

Papers at the Conferen e

"N.A.C.A. Research on VTOL and STOL Aeroplanes," by Mr. M. O. McKinney, N.A.C.A. Langley Aeronautical Laboratory; "Nuclear Mobile Propulsion with Particular Reference to Aircraft," by Dr. J. V. Dunworth, C.B.E., head of Reactor Division, Research Group, U.K.A.E.A.; "Control of Supersonic Propulsion Systems," by Mr. J. C. Sanders, N.A.C.A. Lewis Flight Propulsion Laboratory; "The Electrical Control of Power Plants," by Mr. G. M. Sturrock, Ultra Electric Limited; "Alleviation of Kinetic Heating Stresses," by Mr. J. Taylor, head of Structures Research Division, Royal Aircraft Establishment; "Nine Years of Titanium Usage," by Mr. Leo Schapiro and Mr. Emerson Labombard, Douglas Aircraft Company, Inc.; "The Use of Non-Metallic Materials at High Temperatures," by Dr. W. J. Strang, Bristol Aircraft Limited; "Blast Loading of Aircraft Structures," by Professor R. L. Bisplinghoff and Dr. Emmett A. Witmer, Massachusetts Institute of Technology; "Safety in Relation to Structural Damage," by Dr. A. E. Russell, director and chief engineer, Bristol Aircraft Limited; "An Appraisal of Aeroelasticity in Design, with Special Reference to Aeroelastic Stability," by Mr. Martin Goland, vice-president, Southwest Research Institute; "The Presentation of Information by Aircraft Instruments," by Mr. A. Stratton, Royal Aircraft Establishment; "Increased Usable Lift through Boundary Layer Control," by Mr. C. W. Harper, N.A.C.A. Ames Aeronautical Laboratory; "The Rôle of Experimental Hyperballistics in the Development of Future Aeroplanes and Missiles," by Dr. H. H. Kurzweg, U.S. Naval Ordnance Laboratory; "Design for Repairability of Civil Turbine Engines," by Mr. A. H. Harvey-Bailey, Rolls-Royce Limited; "Aerodynamic Effects of Boundary Layer Unsteadiness," by Mr. F. K. Moore, Cornell Aeronautical Laboratory; "The Human Pilot as an Aircraft Operator," by Squadron Leader T. C. D. Whiteside, R.A.F. Institute of Aviation Medicine.

These papers and the discussions will in due course be published by the Royal Aeronautical Society.

* * *

LOW-SPEED TACHOMETER GENERATOR

For many purposes, particularly with large prime movers, the maximum speed available for driving tachometer generators is as low as 200 r.p.m. It has therefore been necessary to use a chain and sprocket or geared drive to increase the speed to the minimum of 500 r.p.m. which is necessary at the generator itself. This disadvantage has been overcome in the "M" series generator, which has been developed by Smiths Industrial Instruments Limited, North Circular-road, London, N.W.2. By making changes in the circuit arrangement and by incorporating a temperature compensation device it is possible to operate this instrument down to a speed of 200 r.p.m. (corresponding to a full scale reading) with little pointer vibration.

Essentially, the generator consists of a twelve-pole rotor which runs in deep-track ball bearings and a multi-pole staggered slot stator winding, contained in a housing of aluminium alloy.

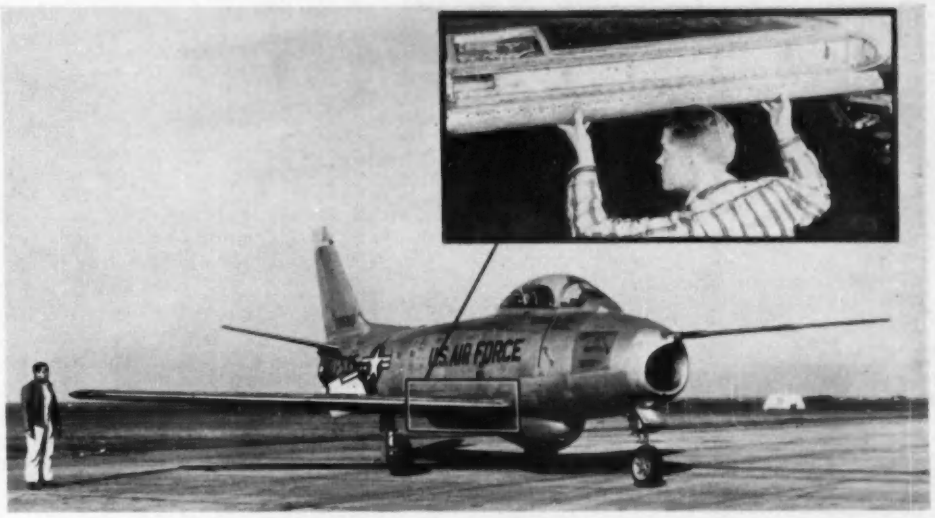


Fig. 4 Full-span leading-edge area suction installed on F.86 aircraft.

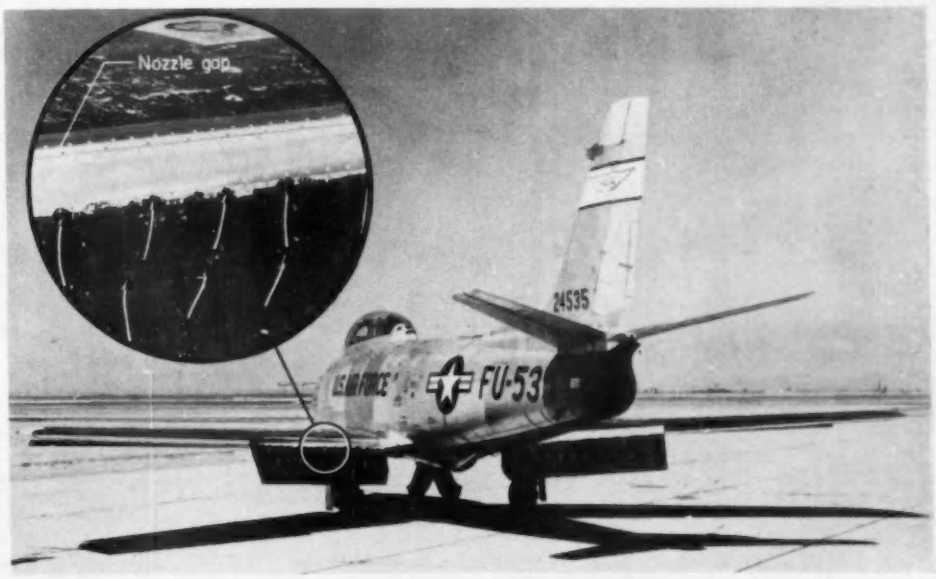


Fig. 5 Jet-blown trailing-edge flap on F.86 aircraft.

Atomic Review

More Out of a Pint Pot

WITHIN certain limits, the greater the output of a reactor the more economic its operation in terms of capital cost. Particularly is this true when the reactor is compact. The nuclear power station to be built at Hinkley Point has a considerably higher electrical capacity than its predecessors at Bradwell, Berkeley and Hunterston. The Berkeley station was described in Atomic Review on December 21 and 28, 1956, and February 1, 1957; the Hunterston station on December 21, 1956, and February 8 and 15, 1957; and the Bradwell station on December 28, 1956, and February 22, 1957. The Hinkley station will profit from technical developments arising since the first tenders were submitted. The increased output is discussed below.

Hinkley Point Contract

The Central Electricity Authority have, subject to clearance of outstanding technical and contractual matters, placed with the English Electric Company, Limited, in association with Babcock and Wilcox Limited and Taylor Woodrow Limited, a contract for the nuclear power station to be built at Hinkley Point, Somerset. This is the conclusion of the direct negotiations that have been going on for some months. The station is scheduled to come into operation by 1962. The total cost of the station and its ancillary works will be in the region of £60,000,000—about £120 per kilowatt. The Hinkley Point nuclear power station will have a net guaranteed electrical output of 500 MW from two graphite-moderated gas-cooled natural-uranium reactors. The 44-acre site is considered suitable for further development in the light of future growth of electricity demand. The general layout of the station is shown in Fig. 1.

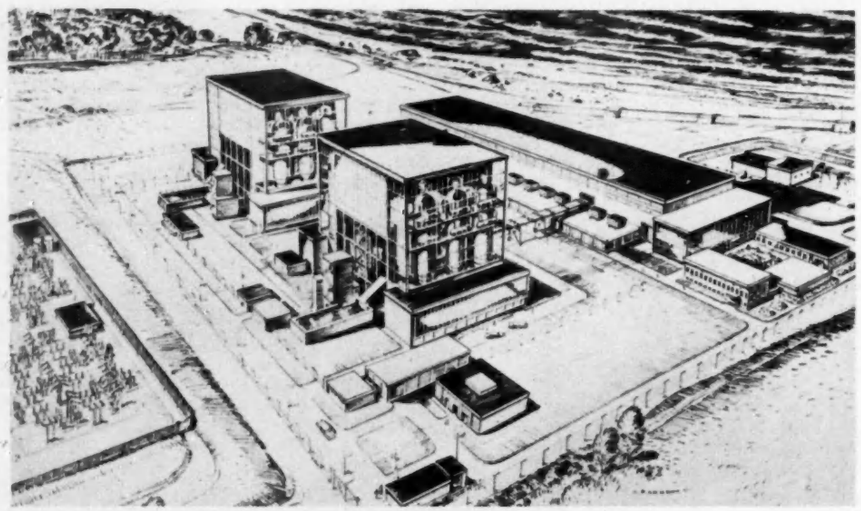


Fig. 1 With an electrical output of 500 MW, the nuclear power station to be built at Hinkley Point, near Bridgwater, Somerset, will have a greater capacity than its predecessors at Berkeley and Bradwell, through of roughly the same size. The contract has been awarded to the group comprising the English Electric Company, Babcock and Wilcox and Taylor Woodrow Construction.

In spite of the increase in output the station is compact and its ground plan is no larger than current 300 MW stations. The buildings fall into three main classes: the two reactor buildings, one of which is illustrated in Fig. 2, with ancillary structures; the turbine house to which is attached a workshop block; and the control, administration and welfare buildings. Three heat exchangers and their related carbon-dioxide blower house are grouped on each side of the two reactor buildings. A diagrammatic view of a heat exchanger appears in Fig. 3. Two spent-fuel storage ponds are sited at the rear of these buildings. The heavy loads of the reactors are transmitted to the sub-strata of limestone and shale through individual foundations. The turbine house has its basement floor level 30 ft. below and its roof level 61 ft. above finished ground level. Each of the reactors produces some 980 MW of heat. Fuel charging is from the top of the reactor and is done on load. Control gear and rods are removable for maintenance with the reactor at full power. The station has six main 93·5 MW turbo-alternator sets.

Overall control of Hinkley Point Station, vested in the station control engineer, is from a central room. There are two reactor control engineers, one for each reactor, and they operate the principal nuclear, steam and electrical controls directly from their control desks. The plant can be inspected by television to safeguard against structural deterioration of reactor parts.

In the extremely unlikely event of a failure of all the gas circulators and emergency supplies simultaneously, the thermo-syphonic circulation of the gas is sufficient to prevent an excessive rise in temperature in the reactors.

The Reactors

The 24-sided core of each reactor is made of graphite blocks and the structure is held in position by bands around the periphery. (The arrangement of a reactor can be seen from Fig. 4.) It is contained in a spherical steel pressure vessel, as shown in Fig. 5, and supported on balls to reduce friction caused by differences in thermal expansion between the metal support plates and the graphite.

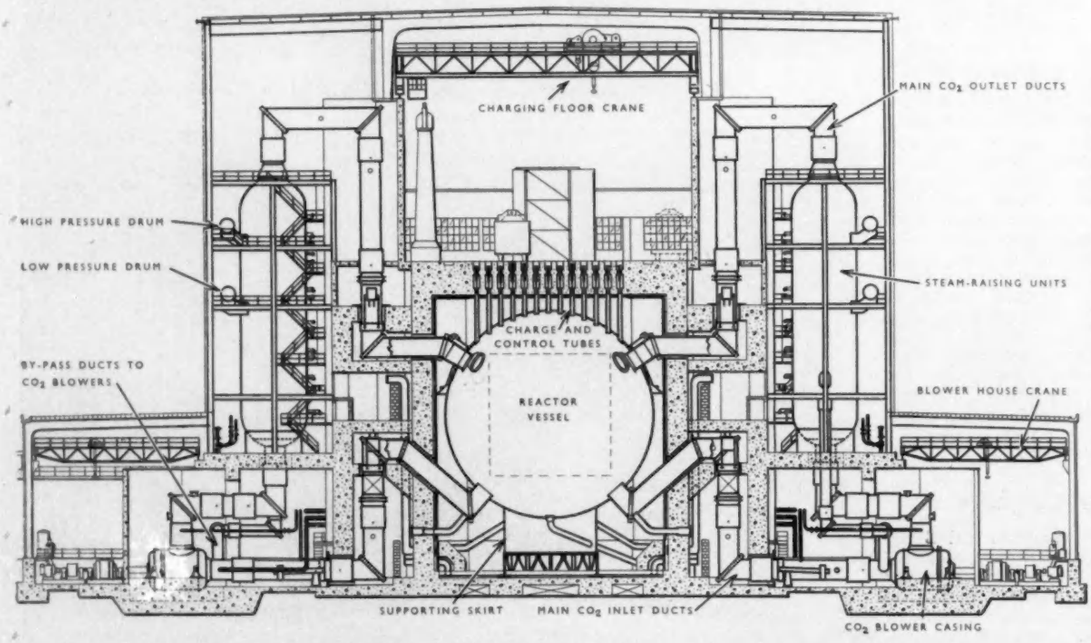


Fig. 2 Sectional view of one reactor building for Hinkley Point. There are two reactors, each with six heat exchangers, and thermal efficiency is 26 per cent. Some efficiency is sacrificed to increased output and economy.

The fuel is loaded from the top through charge pans which locate the top face and give a positive location for the charge machinery. The core is pierced by a lattice of vertical channels through which the fuel elements are lowered into the moderating graphite blocks. Holes for control rods, flux scanning and irradiation of test specimens are formed from chamfers at the four corners of adjacent columns. Shock load, in the event of dropping a fuel element or control rod inadvertently, is absorbed by special devices. The fuel-element supports have a throttle to vary gas flow across the core and so help keep a maximum can temperature over a large part of the core. Each fuel element consists of a cylindrical rod of uranium sealed in a magnesium alloy can.

Flux-fattening elements flatten the radial flux distribution across the reactor. Further dummy elements containing graphite are provided for insertion in the topmost position in each channel in order to reduce both neutron leakage from the reactor and buffeting of the fuel elements underneath by the coolant gas. To detect can failure each group of channels is sampled for a period of 25 seconds every 30 minutes.

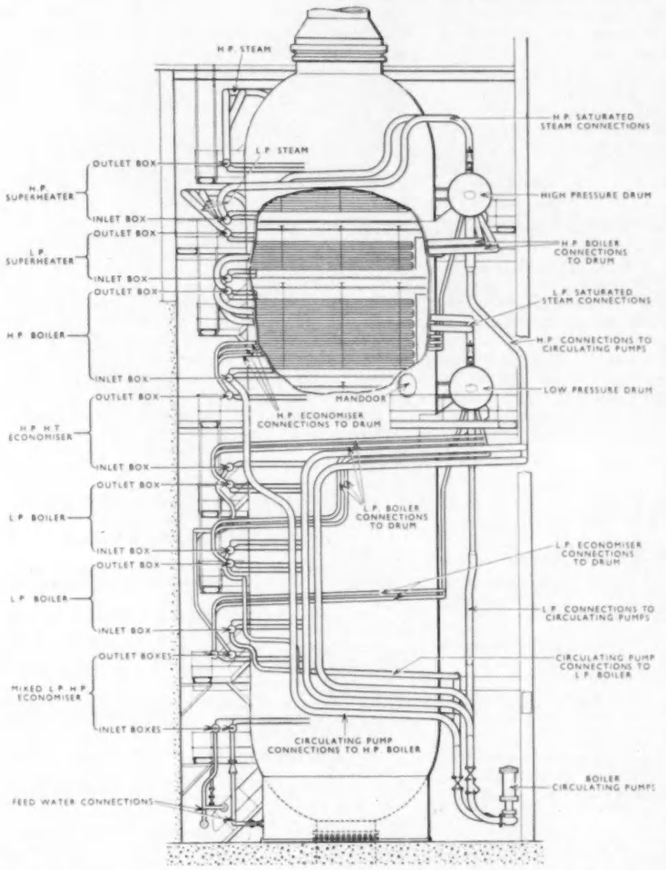


Fig. 3 The steam-raising or heat-exchanger units for Hinkley Point are based on the double-pressure cycle. The arrangement of reactors and heat exchangers is such that thermo-syphonic circulation of the coolant gas is sufficient to prevent an excessive rise of reactor temperature if forced circulation ceases.

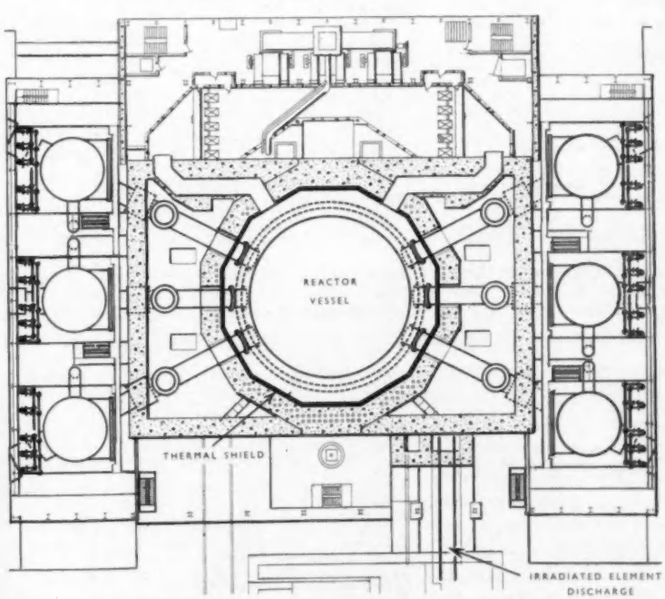


Fig. 4 Sectional plan of reactor and shielding. Charging and discharging of fuel elements can be carried out at full power with the reactor pressurised.

Pressure Vessel

The pressure vessel housing the graphite core has been designed by Babcock and Wilcox Limited, who will also be responsible for its manufacture and erection. The vessel is a sphere 67 ft. in diameter that will be fabricated on site from mild steel boilerplate 3 in. thick. It will be supported on an external cylindrical skirt having a diameter of 30 ft. A structure supported by a similar internal skirt will carry the weight of the reactor core. The design and construction of the pressure vessel comply with the rules of British Standard Specification 1500 (severe duty vessels).

The vessel has twelve openings of 6 ft. 6 in. diameter which receive the main inlet and outlet gas-coolant ducts. In addition, there are about 170 nozzles ranging in diameter from 3 in. to 2 ft., for charging and discharging fuel elements, gas sampling, control-rod insertion, Wigner probes and debris removal. The total weight of the vessel, including nozzles, attachments, lagging and other fittings will be about 1,700 tons. The total load carried by the external skirt of the completed vessel and its internal core and supports will be about 5,500 tons. The design of the reactor support is simple and robust, involving no mechanical joints, sliding parts or rolling surfaces. A thermal device ensures that local discontinuity stresses in the reactor support region are kept within safe limits under all envisaged conditions of operation.

The plates for site-fabrication of the pressure-vessel shell and the cylindrical plates for the support skirts will be preformed, at the company's Renfrew Works, using hydraulic presses of 2,000 and 8,000 tons capacity. The vessel will be stress-relieved " in situ " after erection, and will then be pneumatically tested to $1\frac{1}{2}$ times the design pressure. It will be contained within a reinforced concrete structure that is to be lined with a thermal shield separated from it by cooling air.

The main inlet and outlet ducts carrying the coolant gas between the reactor and steam-raising units will be 6 ft. 6 in. in diameter. To absorb thermal expansion, angular-movement expansion joints are fitted in each duct-run between the two plant components. Shut-off valves will be provided in the system to facilitate the individual isolation of any one of the six gas circuits—containing steam-raising units, coolant circulators and expansion joints—that are associated with each reactor.

Steam-Raising Units

There are six Babcock heat-exchangers associated with each of the two reactors, generating in total over 5·5 million lb. of steam per hour, divided approximately as two-thirds high-pressure and one-third lower-pressure steam. These units are developments of the dual-pressure design of the Calder Hall installation. In the Hinkley Point plant, developments in the properties of the heating surface and in methods of construction and operation enable each unit to have a capacity three and a half times that of a Calder Hall steam-raising unit, although the height and diameter are only 20 per cent. and 25 per cent. greater respectively.

The main vertical shells of the Hinkley Point steam-raising units are 90 ft. high and 21 ft. 6 in. in diameter, with a maximum wall thickness of $2\frac{3}{8}$ in. They are mounted on skirt supports resting on a concrete base. The whole of the steam-raising plant is housed in buildings next to the reactor. Each shell contains seven banks of heating surface made up of individually-supported, flexible, multi-loop, studded elements connected to horizontal external headers through thermal-sleeve openings in the shell wall. Each bank of heating surface is surrounded by baffle

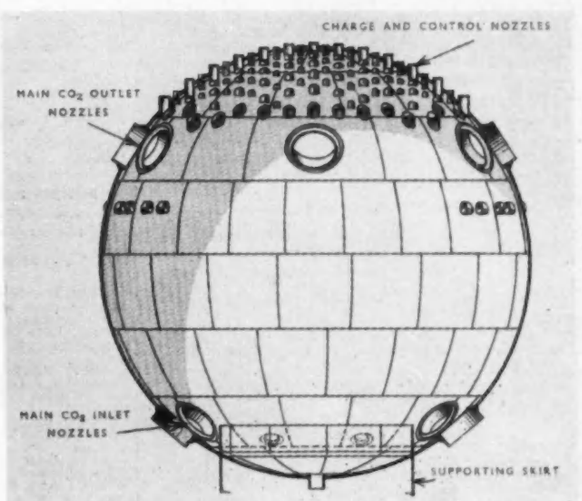


Fig. 5 The spherical pressure vessel for the Hinkley Point reactor is 67 ft. in diameter and fabricated from mild-steel plate 3 in. thick.

Continuing Atomic Review

plating to direct the gas flow. The extended heating surface consists of a multitude of flat studs welded to the tubes. The boiler banks are of forced-circulation design, using glandless centrifugal circulating pumps.

Addendum

At a Press conference, presided over by Mr. H. G. Nelson, managing director of the English Electric Company, Dr. H. S. Arms, chief engineer of the group's atomic energy department, revealed some further details. Mainly he explained how a reactor with a spherical pressure vessel no larger than existing designs—67 ft. internal diameter as against 66 ft. 9 in. (Bradwell) and 70 ft. (Hunterston)—could have an output up to 70 per cent. greater. (Berkeley has a cylindrical vessel.) In the 12 months since the original tenders had been submitted technical developments had produced a series of small improvements; the effect of any one parameter might not be great, but the total gain tended to be the compound product rather than the sum of these small percentages. A 4 per cent. increase in output had been achieved by a modification to the fuel-charging chute, thereby permitting an additional foot of graphite moderator and consequently more uranium and the possibility of improved flux-flattening. The graphite core will be roughly 50 ft. in diameter and 30 ft. high, and there are 8 fuel elements in each 30 ft. channel. The total weight of uranium per reactor will be between 300 and 400 tons (130 at Calder Hall, 240 at Bradwell, 250 at Berkeley, and 251 at Hunterston). It seems possible in addition that a tighter lattice or a larger-diameter fuel rod may have been adopted.

A rise in heat output calls for increased efficiency of heat removal, since the fuel temperature is limited by the properties of the canning material. Improved heat transfer from the fuel element is a first step. At Hinkley Point the fuel rods will be contained in magnesium-alloy cans, with fins part way between the helical fins of BEPO and the transverse fins at Calder Hall—and said to be more efficient than either. The elements are so supported as to counter "Cottrell effect" (see Atomic Review last March 22), and there is an annular clearance between fins and channels.

But ultimately heat transport depends on the carbon-dioxide coolant gas. The gas outlet temperature at Hinkley Point will be just under 390 deg. C. and the gas pressure between 170 and 180 lb per sq. in. (as against 100 at Calder Hall, 150 at Bradwell, and Hunterston, and 125 at Berkeley). The gas flow must also be greater than in earlier designs, the power consumed in the blowers being variable and ranging from 20 to 30 MW. This variation will provide means of control. The gas ducting will be approximately 6 ft. in diameter, but not uniformly so. Total improvements in heat transfer are said to amount to 15 per cent.

The steam conditions on the high-pressure side have been given as 650 lb. per sq. in. and 700 deg. F. (370 deg. C.), with 1·8 as the ratio of mass flow between high and low pressure steam. A constructional advantage is the presence at the site of firm bedrock, on which the reactor foundations can be based, dispensing with the need for large concrete rafts. The distance of the Babcock and Wilcox Renfrew works from Hinkley Point has resulted in the decision to use sea transport for conveying the major plant items.

The thermal efficiency of the station will be about 26 per cent. Comparatively high consumption of power in the gas blowers will be amply compensated by the small bulk per unit output of the station, permitting major economies in capital cost. In consequence the cost of power is expected to be below the national average of 0·65*d.* per kWh.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CARDIFF
Address by the general secretary, E. A. Bromfield. South Wales Branch. Angel Hotel, Westgate-street, Cardiff. Tues., Sept. 24, 7.30 p.m.

CROYDON
"A Talk on the Aims and Objects of the Association," by E. A. Bromfield. South London Branch. Greyhound Hotel, High-street, Croydon. Thurs., Sept. 26, 8 p.m.

British Interplanetary Society

LONDON
"Geophysical Research with Artificial Earth Satellites," by Professor S. F. Singer. Caxton Hall, off Victoria-street, S.W.1. Sat., Sept. 28, 6 p.m.

Building Centre

LONDON
Film: "The First Few Seconds," exhibited by the Pyrene Co., Ltd. Wed., Sept. 25, 12.45 p.m.

Engineering Metrology Association

LONDON
"Micro-Hardness Testing," by R. Wall. Thurs., Sept. 26, 7 p.m.

Engineers' Guild

LONDON
Annual General Meeting. Discussion on the aims and future policy of the Guild. Metropolitan Branch. Caxton Hall, off Victoria-street, S.W.1. Thurs., Sept. 26, 6 p.m.*

Illuminating Engineering Society

BATH
Chairman's Address, by R. H. Hill. Bath and Bristol Centre. Offices of the South Western Electricity Board, Bath. Mon., Sept. 23, 7 p.m.

BIRMINGHAM
Chairman's Address, by G. E. Kemp. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Sept. 27, 6 p.m.

LEICESTER
Induction of A. Y. Johnson as chairman, followed by a display of films. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester (entrance in Rutland-street). Mon., Sept. 23, 7 p.m.

Incorporated Plant Engineers

LONDON
"Reactor Plant Engineering," by R. F. Jackson. General Meeting. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 1, 7 p.m.*

BIRMINGHAM
"Some Principles of Radiant Heating," by P. A. Coles. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Sept. 27, 7.30 p.m.

CARDIFF
Discussions on "Metal Degreasing by Trichloroethylene" and "Metal Pre-Treatment in Industry" (with films). South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Sept. 24, 7.15 p.m.

GLASGOW
Discussions on "Steam" and "Combustion and the Chain Grate Stoker," with films. Glasgow Branch. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow, C.2. Tues., Sept. 24, 7.15 p.m.

LEEDS
"The Safe Use of Electricity," by S. J. Emerson. West and East Yorkshire Branch. The University, Leeds. Mon., Sept. 30, 7.30 p.m.

SHEFFIELD
"Design of Rolling Mills, with Particular Reference to Hot and Cold Ferrous Mills," by M. Langen. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Sept. 26, 7.30 p.m.

Institute of Packaging

SHEFFIELD
Films including "The Harvest of the Forest." Sheffield Branch. Grand Hotel, Sheffield. Mon., Sept. 23, 7.30 p.m.

Institute of Petroleum

LONDON
"Modern Trends in Petroleum Analysis," by Dr. H. Powell and W. H. Thomas; and "Modern Trends in the Instrumentation of Refinery Processes," by S. W. J. Wallis and D. S. Townend. Wed., Oct. 2, 5.30 p.m.*

Institute of Road Transport Engineers

LONDON
Annual General Meeting. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Oct. 3, 6.30 p.m.*

Institution of Civil Engineers

LONDON
"The Design and Construction of the Hindiya Bridge," by J. F. C. Swansbourne. Tues., Oct. 1, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Presidential Address, by T. E. Goldup. Thurs., Oct. 3, 5.30 p.m.*

LEEDS
Chairman's Address, by A. J. Coveney. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Oct. 1, 6.30 p.m.

LOUGHBOROUGH
Informal Conversazione and Reunion. East Midland Centre. Loughborough College, Loughborough. Tues., Oct. 1, 6.30 p.m.*

MANCHESTER
Chairman's Address, by F. R. Perry. North Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Oct. 1, 6.30 p.m.

PORTSMOUTH
Chairman's Address, by Dr. L. G. A. Sims. Southern Centre. Offices of the Southern Electricity Board, Portsmouth. Wed., Oct. 2, 6.30 p.m.

Institution of Engineers-in-Charge

LONDON
Annual General Meeting. Caxton Hall, off Victoria-street, S.W.1. Wed., Oct. 9, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

NEWCASTLE-UPON-TYNE
"Industrial Heating," by P. A. Coles. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Oct. 1, 6.30 p.m.

NOTTINGHAM
Discussion on "Practical Problems of Oil Firing." East Midland Branch. College of Art and Crafts, Waverly-street, Nottingham. Wed., Oct. 2, 6.30 p.m.

Institution of Highway Engineers

LONDON
"Construction of Soil Cement Roads and Road Bases in Holland," by F. A. van der Sluis. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Fri., Oct. 4, 5.30 p.m.

LINCOLN
"Control in the Manufacture and Laying of Bituminous Materials," by H. G. Barnes. Yorkshire and Lincolnshire Branch. Technical College, Lincoln. Thurs., Oct. 3, 7 p.m.

Institution of Locomotive Engineers

LONDON
Presidential Address by E. S. Cox. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Sept. 25, 5.30 p.m.*

Institution of Mechanical Engineers

MANCHESTER
"Principles and Applications of Hydrodynamic-Type Gas Bearings," by G. W. K. Ford, D. M. Harris and D. Pantall. North Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 3, 6.45 p.m.

SHEFFIELD
"The Work of the Standards Engineer in Industry," by H. Stafford. Yorkshire Branch. Royal Victoria Hotel, Sheffield. Wed., Sept. 25, 6.30 p.m.

Institution of Production Engineers

LEICESTER
"Work Measurement and Its Uses for Management," by W. Hewett. Leicester Section. Grand Hotel, Leicester. Fri., Sept. 27, 7 p.m.

NORWICH
"Spheroidal Graphite Iron: A Versatile Engineering Metal," by W. W. Braidwood. Norwich Section. Norwich City College, Ipswich-road, Norwich. Thurs., Sept. 26, 7 p.m.

OXFORD
Discussion on "Transfer Pressing" (with film). Oxford Section. Town Hall, Oxford. Tues., Sept. 24, 7.30 p.m.

SHREWSBURY
"British Clock and Watch Production," by R. Lenoir. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., Sept. 25, 7.30 p.m.

Junior Institution of Engineers

LONDON
Pictorial record of the meeting in Switzerland and of the summer excursion to Crawley, presented by E. M. Baskerville; and film display. Fri., Oct. 4, 7 p.m.*

Physical Society

LONDON
"Sound Propagation in Solids," by Dr. J. W. F. Bell. Acoustics Group. Physics Department, Imperial College, South Kensington, S.W.7. Thurs., Sept. 26, 5.30 p.m.
"Colour and Steelmaking," by Dr. B. O. Smith. Colour Group. Royal Photographic Society, 16 Princes-gate, South Kensington, S.W.7. Wed., Oct. 9, 3.30 p.m.

Women's Engineering Society

MANCHESTER
"Training and Opportunities for Women in Engineering," by Miss Anne Shaw. Manchester Branch, 46 Fountain street, Piccadilly, Manchester. Tues., Sept. 24, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Engineering Metrology Association, Northampton Polytechnic, St. John-street, London, E.C.1. (CLErkenwell 1662.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Packaging. Apply to Mr. H. Williams, 80 Lancaster-avenue, London, S.E.27. (GIPsy Hill 4859.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row London, S.W.1. (VICtoria 0786.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Construction

PORTAL FRAMES FOR OVERHEAD WIRES

The adoption by the British Transport Commission of the 25 kV, 50-cycle system of electric traction will enable smaller overhead collecting wires to be used than those necessary when 1,500 volt direct current is employed, and thus lead to a saving in the weight of the supporting structures. In order to ensure good current collection at all times these wires must be constantly tensioned by means of balance weights throughout the temperature range met. As the temperature varies the wires move along the track, thus applying a torque to the frame of any portal structure used to support them.

To meet these new loading conditions the supporting structure must be designed so that it combines lightness, economy in manufacture, avoidance of obstruction to the sighting of signals and is of good appearance. A prototype structure, of which an illustration appears on this page, has therefore been developed by the traction department of British Insulated Callender's Construction Company, Limited, London, to the requirements of the chief electrical engineer and chief civil engineer, British Railways Central Staff, British Transport Commission, and has recently been tested at the works of Painter Brothers Limited, Hereford.

The structure is made up of 2 in. by 2 in. by $\frac{1}{4}$ in. angles as the main members, to the toes of which $\frac{5}{8}$ in. diameter rod bracing is jig welded. After fabrication the complete structure is galvanised. It is designed for use over five tracks, has a span of 71 ft. and weighs $1\frac{1}{4}$ tons. The heavy type of structure previously used for 1,500 volt direct-current equipment with the same span would weigh about $2\frac{1}{2}$ tons. The design of structures to span three or four tracks will be similar.

During the tests, loads typical of those which would be caused by the equipment and by wind were applied. There was no undue deflection and no permanent "set" when loads of $1\frac{1}{2}$ times the maximum working figure were imposed. Neither did fracture occur when the load was increased to $2\frac{1}{4}$ times the working value. The illustration shows the structure just before the load was applied. Since the tests the design has been modified slightly in order to improve the appearance.

Welded steel portal structure to carry the overhead collecting wires for British Railways alternating-current electrification.

BRITISH CONTRACTORS OVERSEAS

During the twelve months to March 31 last, British building and civil engineering contractors carried out work overseas to the value of £94 million—over £7 million more than in the previous year and a real increase of about £4 million in volume. Nearly 60 firms were engaged overseas in more than 50 countries; some firms were competing in many areas and one—George Wimpey—had contracts in more than 10 countries. The value of this work to British industry as a whole is impossible to calculate but exports of plant and machinery in connection with British contracts ran to £700 million in 1956 and the rate continues to rise by more than 10 per cent. per annum. These figures are given in a circular issued by the Ministry of Works.

The value of new contracts obtained during the year by British firms fell by £17 million to £92 million, but this can be largely attributed to the difficulties in the Middle East. In particular there was a fall in the tenders obtained in Iraq, Kuwait and Cyprus, as well as Australia; on the other hand there were increases in respect of the West Indies, New Zealand, Nigeria and Pakistan. In the sterling area the volume of work carried out was the same in 1957 as in 1956 and there is about the same value of work in hand for the current year.

In the dollar area the situation was very encouraging. Contracts to the value of £29 million were obtained in the year—an improvement of nearly 50 per cent. As various teams have found, it is possible for British companies to get British steel and cement into the far west of Canada cheaper than the local product. Bearing in mind the high constructional activity in Canada—it is substantially higher in terms of dollars per head of population than anywhere else in the world—it is to be hoped that British firms will be able to take advantage of the situation there. One of the largest contracts in progress in Canada by a British firm is that for a new headquarters building for the Federal Tax Department in Montreal; Holland & Hannan and Cubitts are doing this work for around 9 million dols.

Contracts were obtained in a number of countries during 1956-57 where none had been obtained in the previous 12 months; for example, in Burma, Norway, Qatar and Portuguese East Africa, and in Italy where no work at all had been in progress during 1956.

Building costs rose in most countries last year. Compared with the increase of 5 per cent. at home, the increases elsewhere showed a wide variation. In France, for example, the increase was as much as 12 per cent., but in Italy and Portugal it was as little as 1 per cent. In the United States and Canada prices rose, as here, by 5 per cent., and probably between 4 and 5 per cent. must be allowed for price increases in assessing the rise in volume of overseas work undertaken by British firms during last year. Among the work notified for next year and for which tenders have been or will be let are the following: a hydro-electric power station at the Keepit Dam, New South Wales; a similar station near Cressy in Tasmania; a bridge over the river Chari at Fort Lamy, Chad, French Equatorial Africa; and the construction of a thermal station on the River Limay, at Neuquen, in the Argentine.

★ ★ ★

HIGH-SPEED RAILWAY SWITCHES

To meet the need for higher speeds envisaged under modernisation plans now in hand on British Railways, the Southern Region has developed two new switches in 109 lb. F.B. rail. They are the "Curved-F" and "G" switches and are both of the chamfered type which, by undercutting of the stock rail permits sufficient metal in the switch rail to provide a section sufficiently robust at and near the switch toe for the very fine entry angles used. Characteristic dimensions for the curved-F and G switches are, respectively: crossing angle, 1 in 20 and 1 in 24; radius of switch curve and turnout curve, 58 and 81 chains.

On the Southern Region, where prototypes of the two switches have already been laid, a speed restriction of 50 m.p.h. is considered desirable for curved-F switches diverging from the straight. G switches will be used where higher speed restrictions, of up to 75 m.p.h., are required and where site conditions permit.

INTERNATIONAL CONDITIONS OF CONTRACT

The publication of an internationally agreed "Conditions of Contract for Works of Civil Engineering Construction" is a step likely to be welcomed by civil and constructional engineers throughout the world. The document, which is the culmination of two years' joint discussion and negotiation, has been approved by both the International Federation of Consulting Engineers and the International Federation of Building and Public Works. The United Kingdom National Federation of Building Trades Employers consider that the document "holds the balance fairly between employers and contractors" and that it should prove "of great assistance to employing authorities and others responsible for development programmes."

The acceptance of this document by the two international federations named above and its endorsement by these bodies for general use is something of a triumph for British practice, and particularly for Mr. Julian S. Tritton, who has been mainly responsible for stating the British point of view. In nearly all respects the document closely follows accepted British practice and is based on the British conditions of contract except for some minor re-wording required by differences between British and Continental law. The principal difference concerns the practice of placing the full onus on the contractor for checking all data and calculations for a scheme which are furnished by the employer (or his consulting engineers). In the agreement there is a slightly different emphasis on the responsibility of the employer or consulting engineer, *vis-à-vis* the contractor, who is no longer invariably required to put right at his own expense any faults arising through erroneous instructions or drawings. There is also a clause which provides for a bonus payment in the event of a contract being completed before time.

The acceptance of this international Conditions of Contract may bring about a change in the American and European practice of cutting out the consulting engineer. There has been a tendency for some time to allow the contractor to do both the design and the construction. Yet British evidence gives strong support to the rôle of the independent consultant who confines his work to the design of a scheme. The unrivalled experience British consulting engineers have of this work overseas, and the immense amount of it being carried out or on order at the present time, suggests that the consulting engineer will have a golden opportunity to reassert his interests.

The Human Element

Innocents in Industry

Recent correspondence in *The Times* has helped to focus attention on a problem of employment which requires a great deal more than it has received so far. It was started by Mr. Bernard Levy as a plea for university appointments boards which are something more than " clearing agencies for those who already know what they want." He points out that the resources devoted to this kind of service are most inadequate: " with a few noteworthy exceptions, the overworked staff of these boards do not have time to give their applicants the individual attention and advice that is needed." The resultant aimless wandering of the arts graduate in depressingly " temporary " posts, living in the hope that " the right job will come along some time " is a shocking waste of manpower and talent.

Other letters generally support the case which Mr. Levy has made out for clearer advice to arts graduates on the limitations which they must accept and the lines which they might most carefully explore. The appointments boards could take a leaf out of industry's book and keep in close touch with the graduates who most need their help, the non-specialists, and their scope widened to enable them to be " of more genuine service in giving vocational assessment and advice over the entire three years of an undergraduate's course."

The need of these young people who leave university with no clear conception of what their careers shall be is for greater understanding of industry. If this were forthcoming so would vanish most of the prejudices that tend to hold them back from industrial careers and, more particularly, from what Mr. Levy calls " the routine of commerce." The non-specialist can be used in industry—as a co-ordinator of the activities of his scientific colleagues. As an arts graduate points out, the non-specialist must come down to earth and discard prejudice but so also must industry give more time and more thought to the successful enrolment of this type of man.

Brain Signals

The psychological aspects of learning received a great deal of attention at the meeting of the British Association for the Advancement of Science in Dublin last week. Several papers were given on the acquisition of skill and the various elements involved in performing an operation skilfully. One paper, read by Mr. J. Annett, " Perceptual Organisation in Simple Skills," is a fairly technical discussion of the " highly organised activity " exhibited in the performance of a skilled job. To understand how skill is exercised—essentially through " organisation " by the brain of a large number of " input signals "—it is necessary to study these signals as well as the controlled activity, " motor output " which results. Mr. Annett points out that the field of study therefore extends beyond the movements involved. He predicts that much more will be learned about how skills are acquired and how skilled activity is organised " by looking at the organisation of the input signals rather than the more obvious overt behaviour."

Other papers concerned with this problem included " The Rôle of Attention in Skill, With a Mechanical Analogy," by Mr. D. E. Broadbent, which described how the General Electric Company of America has made use of psychologists to help in the development of heavy missile guidance systems: complex semi-automatic sytems need to be " designed so that a man can use them efficiently, and therefore experiments on human behaviour are needed before the system will work properly." The experiments, conducted with human beings by presenting signals for action and observing the results, were described and their application to mechanical devices explained.

In other fields (including operational research) attention is also being paid to, and progress made, in the definition of the factors in skill and the findings are being applied to the development of training techniques. Some of the results obtained are remarkable enough to suggest that great strides are imminent in this field of knowledge.

Father to the Man

The striking successes obtained from time to time by the Royal Air Force in training boys is evidence enough that the glamour of the Force attracts first-class material. A paper read to the British Association by Mr. A. B. Cherns and Mr. K. W. Tilley, " Social Factors in Training of Royal Air Force Boy Entrants," discusses some of the problems involved and reviews the progress made so far.

The paper describes the results of a two-year research programme into the hypothesis that social factors contributed at least as highly as intelligence and education to the results of training. This was undertaken after earlier research had shown that " the outcome of a boy's training depends only partly upon his intelligence and previous attainments." A sample of 120 boys were interviewed in five successive terms. Having obtained what the authors call " sociometric data," i.e., information about the boys' social background and family life, they found that, though the sample was not heavily weighted in the boys from broken homes, the presence in the home of adults *in loco parentis* was a handicap, as was the absence of the boy's own mother.

Some of the conclusions reached are of absorbing interest as well as of great value to the educationist. Most headmasters and teachers would benefit from the realisation that " what makes a boy unhappy or disaffected is not so much his difficulty in coping with his curriculum as his relations with his fellows and his identification with the aim of his training; for this to be successful he has to accept the Service's values and objectives as his own. Only when his personal relations and identification with the Service are satisfactory is it possible for a boy to devote his intelligence to passing his course." Intelligence does not appear to play a part in the process of psycho-social adjustment: this is " controlled rather by the boy's personality and his motivation."

Backwardness and Brightness

An interesting experiment into the connection between verbal intelligence, reading comprehension and mechanical arithmetic on the one hand and ten environmental factors on the other in the case of children has been made in recent years by the University of Manchester School of Education. This experiment was described in a paper at the British Association by Dr. Stephen Wiseman. The rates for these variables were correlated with the incidence of brightness and backwardness. These last two were fairly arbitrarily defined as the top and bottom 16 per cent. of the population tested.

The survey covered nearly 14,000 children in 270 schools. The sample analysed consisted of 3,317 children in the Manchester area. It was confined to secondary modern and all-age schools. It thereby excluded, one will note, the best and the worst. The inter-relationships between the 16 variables were analysed using the computer at the University of Manchester.

The brief outcome of this experiment is the strong evidence that backwardness and brightness are not just the obverse and reverse of the same set of conditions. Backwardness seems to be connected mainly with innate dullness and this with a bad social background. Economic conditions seem to have little to do with it. Parental care seems to be connected with brightness in reading in a psychological as well as a physical sense.

White Boys' Burden

A specially vile form of maltreatment is reserved for mechanical equipment shipped out to backward areas where local servicing arrangements are at best rudimentary. It is not difficult to persuade people with no industrial background that they should have lorries and modern factory equipment. It is quite another matter to inculcate the idea that this equipment needs care in treatment and systematic maintenance.

Leyland Motors Limited have introduced an interesting scheme for helping to train Africans in engine maintenance. Trade apprentices at the Leyland and Albion factories have produced sectioned engines to show main and ancillary parts. These are being shipped to West and East Africa to be used in training schools set up by their agents in Ghana, Nigeria and Kenya. From Leyland have gone 100 horse-power units to West Africa where Comet trucks are in service. From Albion Motors have gone such items as a 4-cylinder Diesel engine with gearbox and differential unit.

Without Men

At the Summer School this year organised by the National Coal Board, the chairman of the Board once again drew attention to the dangers of absenteeism. He kept this point until late in his remarks and it may therefore be assumed that it is a matter of acute concern to the N.C.B. The recent rate of absenteeism has been worse than in the earlier months of this year or than the average of 1956—which was in itself quite substantial. The coal industry has all the more reason to be sickened by the recent figure after the concession granted earlier this year on the bonus shift, which the N.C.B. made after considerable misgivings about its effect on absenteeism.

The basic contradiction in this performance is, however, that it makes nonsense of any major programme of mechanisation. The long-term prosperity of the United Kingdom coal industry depends on such a programme. On its implementation hangs the future standard of living of the miners themselves. Yet such machines must be kept fully employed if they are to pay their way, and they cannot do so with an absentee rate in the industry of over 13 per cent. In any other industry this would be considered bad enough for the absentee rate during the height of the winter sickness period. It is axiomatic that men need machines to keep competitive in this day and age—but the reverse is equally true, that machines need men.

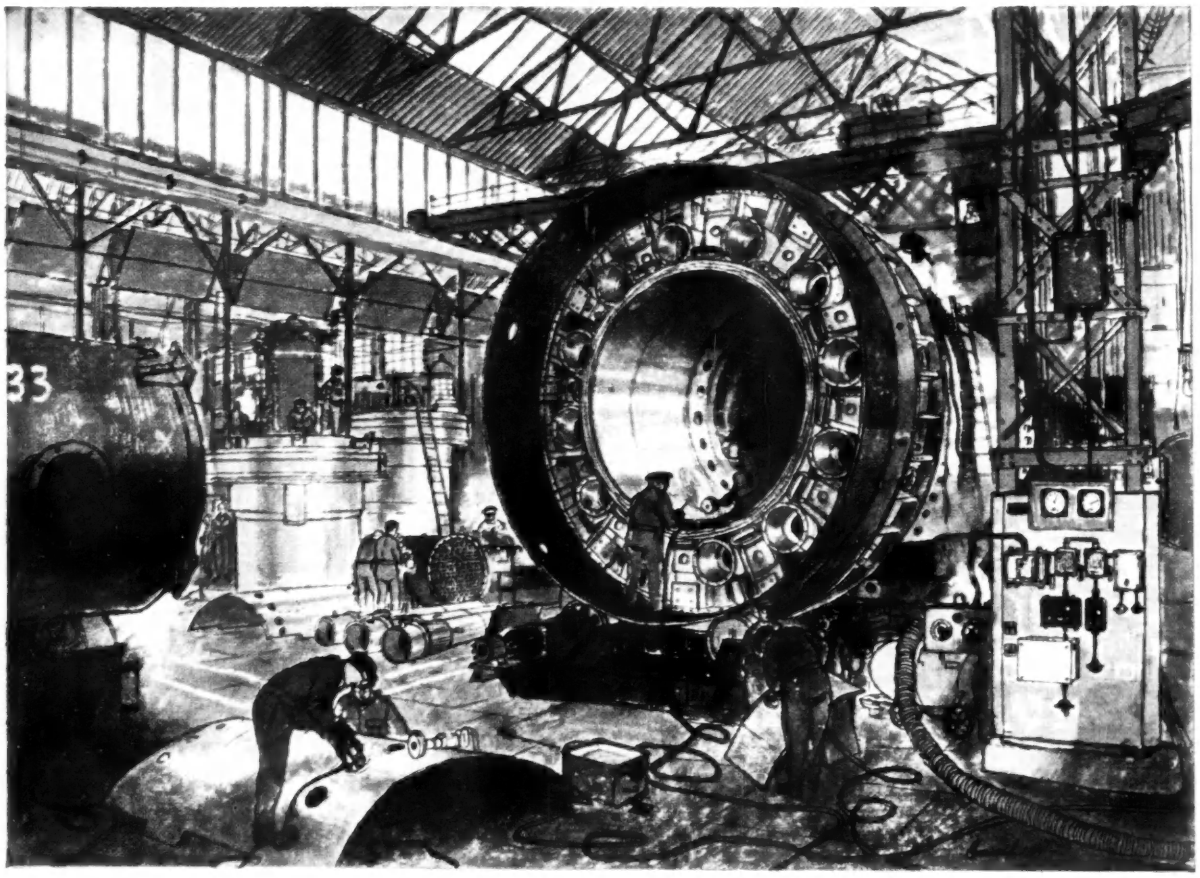
Fly Away Jock

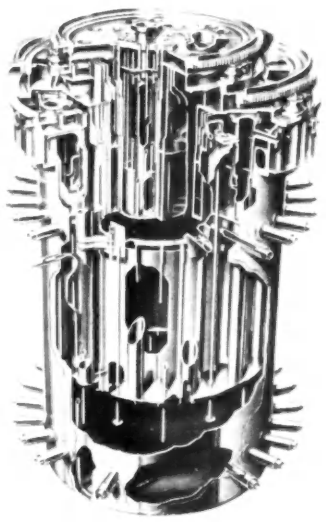
Concern was expressed some time ago by the Scottish T.U.C. about the high emigration rate from Scotland. A committee was set up to look into the problem but the interim report admits defeat as to what are the main causes. The investigation is to continue.

Briefly, Scotland has for long turned out a high proportion of educated men and women who have been too numerous for the number of openings available. Education for all has gone hand-in-hand with rural depopulation and cyclical unemployment. The disagreement has been as to how far the Highlands in particular, which produce a high proportion of intelligent but a not-so-high proportion of industrious people, should be subsidised or " artificially " stimulated by the State. Equally, the problem is still to be solved as to how far the industrial economy can be diversified. These remain the urgent problems if emigration is to be slowed.

ENGINEERING

An Illustrated Weekly Journal





The most complicated stainless steel vessel ever made

The Dounreay reactor vessel is a complex 45-ton stainless steel vessel with eccentric rotating top shields and will contain the core, breeder blanket, control rod operating mechanisms, recording instruments and the liquid-metal which is circulated to the primary heat exchangers. Every welded joint was radiographed, requiring 3750 negatives. The whole unit is manufactured to very fine tolerances—0·1" circularity, 0·03" alignment and almost perfect concentricity.

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